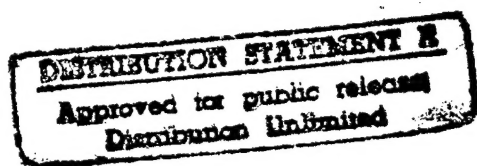


INSTALLATION RESTORATION PROGRAM

COLORADO AIR NATIONAL GUARD
BUCKLEY AIR NATIONAL GUARD BASE, AURORA, COLORADO

REMEDIAL INVESTIGATION REPORT VOLUME I



August 1995

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Environmental Management and Enrichment Facilities
Oak Ridge, Tennessee 37831-7606
managed by MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

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INSTALLATION RESTORATION PROGRAM

**REMEDIAL INVESTIGATION REPORT
VOLUME I**

Colorado Air National Guard
Buckley Air National Guard Base
Aurora, Colorado

August 1995

Prepared for
AIR NATIONAL GUARD READINESS CENTER
Andrews Air Force Base, Maryland 20331-5157

Prepared by
Science Applications International Corporation
14062 Denver West Parkway, Suite 200
Golden, Colorado

Submitted by
HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Management and Enrichment Facilities
Oak Ridge, Tennessee 37831-7606
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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TABLE OF CONTENTS

PAGE NO.

EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 SITE BACKGROUND INFORMATION AND PREVIOUS STUDIES	1-3
1.1.1 Installation Restoration Program Phase I Records Search (Preliminary Assessment)	1-3
1.1.2 Site Investigations (SIs)	1-7
1.2 OVERVIEW OF REPORT	1-8
2.0 REMEDIAL INVESTIGATION ACTIVITIES AND APPROACH	2-1
2.1 FIELD PROGRAM ACTIVITIES AND PROCEDURES	2-1
2.1.1 Soil-Gas Surveys and Procedures	2-2
2.1.2 Surface Electromagnetic Conductivity Survey	2-3
2.1.3 Monitoring Well Drilling, Installation, and Sampling	2-3
2.1.4 Soil Boring Drilling, Sampling, and Abandonment	2-9
2.1.5 Sediment Sampling	2-12
2.1.6 Hydrologic Data Collection	2-12
2.1.7 Equipment Decontamination	2-13
2.2 DATA ANALYSES PROCEDURES AND INFORMATION (RI PART 1)	2-13
2.2.2 Chemical Analysis QA/QC Assessment Summary (RI Part 1)	2-14
2.2.1.1 Field QA/QC Samples (RI Part 1)	2-14
2.2.1.2 Laboratory QA/QC Samples (RI Part 1)	2-15
2.2.1.3 Adherence to Sampling and Analysis Protocols and Pro- cedures (RI Part 1)	2-15
2.2.1.4 Summary of QA/QC Assessment Results (RI Part 1)	2-16
2.2.2 Chemical Analyses Data Evaluation Methods (RI Part 1)	2-16
2.2.3 Data Quality Assessment (RI Part 2)	2-16
2.2.3.1 Data Quality Objectives	2-19
2.2.3.1.1 Precision	2-19
2.2.3.1.2 Accuracy	2-20
2.2.3.1.3 Representativeness	2-21

TABLE OF CONTENTS (CONTINUED)

	PAGE NO.
2.2.3.1.4 Comparability	2-22
2.2.3.1.5 Completeness	2-22
2.2.4 Public Health Risk Assessment Summary	2-23
3.0 REGIONAL ENVIRONMENTAL SETTING	3-1
3.1 HYDROGEOLOGY	3-1
3.1.1 Regional Hydrogeologic System	3-1
3.1.1.1 Regional Geologic Framework	3-1
3.1.1.2 Regional Hydrogeology	3-3
3.1.1.3 Groundwater Use and Development	3-6
3.1.1.4 Water Quality of the Denver Aquifer	3-6
3.1.2 Base-wide Hydrogeology	3-7
3.2 BACKGROUND SAMPLING RESULTS	3-14
3.2.1 Monitoring Well Borehole Soil Sample Results	3-14
3.2.2 Groundwater Results	3-14
3.2.3 Background Groundwater Contaminant Concentration Comparisons to ARARs	3-19
4.0 SITE 1 - FORMER BASE LANDFILL AND FORMER OIL PIT	4-1
4.1 SITE DESCRIPTION AND PREVIOUS WORK	4-1
4.2 REMEDIAL INVESTIGATION ACTIVITIES	4-3
4.3 SITE HYDROGEOLOGY	4-4
4.4 RESULTS AND SIGNIFICANCE OF FINDINGS	4-4
4.4.1 Surface EM Conductivity Survey Results	4-4
4.4.2 Soil Boring Soil Sample Results	4-16
4.4.3 Monitoring Well Borehold Soil Sampling Results	4-20
4.4.4 Groundwater Sample Results	4-20
4.4.5 Stream Sediment Sample Results	4-25
4.5 SUMMARY OF FINDINGS	4-27
4.6 RISK ASSESSMENT RESULTS	4-27

TABLE OF CONTENTS (CONTINUED)

PAGE NO.

4.6.1 Groundwater Consumption Risks	4-27
4.6.2 Soil and Sediment Exposure Risks	4-31
4.7 CONCLUSIONS AND RECOMMENDATIONS	4-31
5.0 SITE 2 - FORMER FIRE TRAINING AREA #1	5-1
5.1 SITE DESCRIPTION AND PREVIOUS WORK	5-1
5.2 REMEDIAL INVESTIGATION ACTIVITIES	5-3
5.3 SITE HYDROGEOLOGY	5-3
5.4 RESULTS AND SIGNIFICANCE OF FINDINGS	5-6
5.4.1 Soil-Gas Survey Results	5-6
5.4.2 Monitoring Well Borehole Soil Sample Results	5-6
5.4.3 Groundwater Sample Results	5-6
5.5 SUMMARY OF FINDINGS	5-9
5.6 RISK ASSESSMENT RESULTS	5-9
5.6.1 Groundwater Consumption Risks	5-9
5.6.2 Soil and Sediment Exposure Risks	5-9
5.7 CONCLUSIONS AND RECOMMENDATIONS	5-12
6.0 SITE 3 - FORMER FIRE TRAINING AREA #2	6-1
6.1 SITE DESCRIPTION AND PREVIOUS WORK	6-1
6.2 REMEDIAL INVESTIGATION ACTIVITIES	6-3
6.3 SITE HYDROGEOLOGY	6-3
6.4 RESULTS AND SIGNIFICANCE OF FINDINGS	6-8
6.4.1 Soil-Gas Survey Results	6-8
6.4.2 Soil Boring Soil Sample Results	6-12
6.4.3 Monitoring Well Borehole Soil Sample Results	6-16
6.4.4 Groundwater Sample Results	6-19
6.5 SUMMARY OF FINDINGS	6-21
6.6 RISK ASSESSMENT RESULTS	6-21
6.6.1 Groundwater Risks	6-21
6.6.2 Soil Exposure Risks	6-23

TABLE OF CONTENTS (CONTINUED)

	PAGE NO.
6.7 CONCLUSIONS AND RECOMMENDATIONS	6-23
7.0 SITE 4 - FIRE TRAINING AREA #3	7-1
7.1 SITE DESCRIPTION AND PREVIOUS WORK	7-1
7.2 REMEDIAL INVESTIGATION ACTIVITIES	7-1
7.3 SITE HYDROGEOLOGY	7-3
7.4 RESULTS AND SIGNIFICANCE OF FINDINGS	7-11
7.4.1 Soil-Gas Survey Results	7-11
7.4.2 Soil Boring Soil Sample Results	7-15
7.4.3 Monitoring Well Borehole Soil Sample Results	7-20
7.4.4 Groundwater Sample Results	7-25
7.5 SUMMARY OF FINDINGS	7-29
7.6 RISK ASSESSMENT RESULTS	7-29
7.6.1 Groundwater Consumption Risks	7-29
7.6.2 Soil Exposure Risks	7-31
7.7 CONCLUSIONS AND RECOMMENDATIONS	7-31
8.0 SITE 5 - DRAINAGE DITCH	8-1
8.1 SITE DESCRIPTION AND PREVIOUS WORK	8-1
8.2 REMEDIAL INVESTIGATION ACTIVITIES	8-3
8.3 SITE HYDROGEOLOGY	8-3
8.4 RESULTS AND SIGNIFICANCE OF FINDINGS	8-3
8.4.1 Surficial Sediment Sample Results	8-3
8.5 SUMMARY OF FINDINGS	8-7
8.6 RISK ASSESSMENT RESULTS	8-7
8.6.1 Soil and Sediment Exposure Risks	8-7
8.7 CONCLUSIONS AND RECOMMENDATIONS	8-9
9.0 SITE 6 - FORMER SEWAGE TREATMENT PLANT	9-1
9.1 SITE DESCRIPTION AND PREVIOUS WORK	9-1
9.2 REMEDIAL INVESTIGATION ACTIVITIES	9-3
9.3 SITE ENVIRONMENTAL SETTING	9-3

TABLE OF CONTENTS (CONTINUED)

	PAGE NO.
9.4 SIGNIFICANCE OF FINDINGS	9-7
9.4.1 Surficial Sediment Sample Results	9-7
9.4.2 Soil Boring Soil Sample Results	9-7
9.4.3 Groundwater Sample Results	9-7
9.5 SUMMARY OF FINDINGS	9-12
9.6 RISK ASSESSMENT RESULTS	9-12
9.6.1 Groundwater Consumption Risks	9-12
9.6.2 Soils and Sediments Exposure Risks	9-14
9.7 CONCLUSIONS AND RECOMMENDATIONS	9-14
LIST OF ACRONYMS AND ABBREVIATIONS	A-1
REFERENCES	R-1

LIST OF TABLES

TABLE	TITLE	PAGE NO.
1-1	Reference Chart for the Chronology, Purpose, and Terminology Used in IRP Studies Conducted at Colorado Air National Guard, Buckley Field, Aurora, Colorado	1-2
2-1a	Summary of Methods for Analysis of Soil and Water Sample Colorado Air National Guard, Buckley Field, Aurora, Colorado Remedial Investigation: Part 1	2-5
2-2a	Summary of Sample Containers, Preservation Techniques, and Holding Times of Water and Soil Samples According to Measurement, Colorado Air National Guard, Buckley Field, Aurora, Colorado Remedial Investigation: Part 1	2-6
2-1b	Summary of Methods for Analysis of Soil and Water Samples, Colorado Air National Guard, Buckley Field Aurora, Colorado Remedial Investigation: Part 2	2-10
2-2b	Summary of Sample Containers, Preservation Techniques, and Holding Times of Water and Soil Samples According to Measurement, Colorado Air National Guard, Buckley Field, Aurora, Colorado Remedial Investigation: Part 2	2-11
2-3	Summarization of Compounds Found in Field and Laboratory Blanks at Colorado Air National Guard, Buckley Field, Aurora, Colorado	2-17

LIST OF TABLES (CONTINUED)

TABLE	TITLE	PAGE NO.
3-1	Static Groundwater Elevations for Colorado Air National Guard, Buckley Field, Aurora, Colorado	3-8
3-2	Aquifer Test Results, Colorado Air National Guard, Buckley Field, Aurora, Colorado	3-9
3-3	Summary of Inorganic and Organic Compounds Detected in Background Soil Samples, Colorado Air National Guard, Buckley Field, Aurora, Colorado	3-16
3-4	Comparisons of Background Soil Sample Results with Published Background Levels of Selected Trace Metals in Soil (PPM)	3-17
3-5	Summary of Inorganic and Organic Compounds Detected in Background Groundwater Samples, Colorado Air National Guard, Buckley Field, Aurora, Colorado	3-18
3-6	ARARS for Inorganic Chemicals for Background Groundwater at the Buckley ANGB	3-20
4-1	Analytical Results for Site 1 - Former Base Landfill and Former Oil Pit	4-2
4-2a	Remedial Investigation Sample Analysis Summary for Site 1 - Former Base Landfill, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 1	4-6
4-2b	Remedial Investigation Sample Analysis Summary for Site 1 - Former Base Landfill, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 2	4-7
4-3	Summary of Inorganic and Organic Compounds in Soil Samples at Site 1 - Former Base Landfill, Colorado Air National Guard, Buckley Field, Colorado, Remedial Investigation: Part 1	4-17
4-4a	Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 1 - Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 1	4-22
4-4b	Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 1 - Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2	4-23
4-5	Summary of Inorganic and Organic Compounds Detected in Sediment Samples at Site 1 - Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 1	4-26
4-6	ARARs for Inorganic Chemicals from Site 1 - Groundwater at the Buckley ANGB	4-28
4-7	Risk Characterization for Site 1: Groundwater Exposure	4-30

LIST OF TABLES (CONTINUED)

TABLE	TITLE	PAGE NO.
4-8	Risk Characterization for Site 1: Exposure to Sediments	4-32
4-9	Risk Characterization for Site 1: Soil Exposure	4-33
5-1	Analytical Results for Site 2 - Former Fire Training Area No. 1	5-2
5-2	Remedial Investigation Sample Analysis for Site 2 - Former Base Fire Training Area No. 1, Buckley Field, Aurora, Colorado	5-5
5-3	Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 2 - Former Fire Training Area No. 1, Colorado Air National Guard, Buckley Field, Aurora, Colorado	5-7
5-4	Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 2 - Former Fire Training Area No. 1, Colorado Air National Guard, Buckley Field, Aurora, Colorado	5-8
5-5	ARARs for Inorganic Chemicals from Site 2 Groundwater at the Buckley ANGB	5-10
5-6	Risk Characterization for Site 2: Soil Exposure	5-11
6-1	Analytical Results for Site 3 - Former Fire Training Area No. 2	6-2
6-2a	Remedial Investigation Sample Analysis Summery for Site 3 - Former Fire Training Area No. 2, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 1	6-5
6-2b	Remedial Investigation Sample Analysis Summery for Site 3 - Former Fire Training Area No. 2, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 2	6-6
6-3a	Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 3 - Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 1	6-13
6-3b	Summary of Investigation Sample Analysis Summery for Site 3 - Former Fire Training Area No. 2, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 2	6-17
6-4	Summary of Inorganic and Organic Compounds Detected in Groundwater at Site 3 - Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado	6-20
6-5	ARARs for Inorganic Chemicals from Site 3 Groundwater at the Buckley ANGB, Remedial Investigation: Part 1	6-22
6-6	Risk Characterization for Site 3: Soil Exposure	6-24
7-1	Analytical Results for Site 3 - Former Fire Training Area No. 2	7-2
7-2a	Remedial Investigation Sample Analysis Summary for Site 4 - Base Fire Training Area No. 3, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 1	7-5

LIST OF TABLES (CONTINUED)

TABLE	TITLE	PAGE NO.
7-2b	Remedial Investigation Sample Analysis Summary for Site 4 - Base Fire Training Area No. 3, Buckley Field, Colorado Air National Guard, Aurora, Colorado, Remedial Investigation: Part 2	7-6
7-3a	Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 1	7-16
7-3b	Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2	7-21
7-4a	Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 1	7-26
7-4b	Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2	7-28
7-5	ARARs for Inorganic Chemicals from Site 4 Groundwater at the Buckley ANGB	7-30
7-6	Risk Characterization for Site 4: Soil Exposure	7-32
8-1	Analytical Results for Site 5 - Storm Drainage System	8-2
8-2	Remedial Investigation Sample Analysis Summary for Site 5 Storm Drainage System, Buckley Field, Colorado Air National Guard, Aurora, Colorado	8-5
8-3	Summary of Inorganic and Organic Compounds Detected in Sediment Samples at Site 5 - Storm Drainage System, Colorado Air National Guard, Buckley Field, Aurora, Colorado	8-6
8-4	Risk Characterization for Site 5: Exposure to Sediments	8-8
9-1	Analytical Results for Site 6 - Former Sewage Treatment Plant	9-2
9-2	Remedial Investigation Sample Analysis Summary for Site 6 - Former Base Sewage Treatment System, Buckley Field, Colorado Air National Guard, Aurora, Colorado	9-5
9-3	Summary of Inorganic and Organic Compounds Detected in Sediment Samples at Site 6 - Former Base Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado	9-8
9-4	Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 6 - Former Base Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado	9-9

LIST OF TABLES (CONTINUED)

TABLE	TITLE	PAGE NO.
9-5	Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 6 - Former Base Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado	9-11
9-6	ARARs for Inorganic Chemicals from Site 6 Groundwater at the Buckley ANGB	9-13
9-7	Risk Characterization for Site 6: Exposure to Sediments	9-15
9-8	Risk Characterization for Site 6: Soil Exposure	9-16

LIST OF FIGURES

FIGURE	TITLE	PAGE NO.
1-1	Site Location Map for Colorado Air National Guard, Buckley Field, Aurora, Colorado	1-4
2-1	Above Ground Monitoring Well Completion, Buckley ANGB, CO.	2-8
3-1	Index Map of the Denver Basin and Generalized Geologic Section. (Modified from Robson and Romero, 1981b).	3-2
3-2	Conceptual Model of the Regional Hydrogeologic System at Buckley ANGB, Aurora, Colorado. (Modified from Heath, 1984).	3-4
3-3	Surficial Geology at Buckley ANGB (Simons, Li & Assoc., 1982)	3-11
3-4	Generalized Geologic Cross Section at Buckley ANGB. See Figure 3-3 for Cross Section Location (Dames and Moore, 1987; Modified from Robson and Romero, 1981b)	3-12
3-5	Location of Background Monitoring Wells, Colorado Air National Guard, Buckley Field, Aurora, Colorado	3-15
4-1	Field Activity Locations for Site 1 Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-5
4-2	Generalized Geologic Profile A-A' of Site 1 - Former Landfill Area, Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-8
4-3	Generalized Geologic Profile B-B' of Site 1 - Former Landfill Area, Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-9
4-4	Generalized Geologic Profile C-C' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil at Site 1 - Former Base Landfill Area, Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-10
4-5	Potentiometric Surface Map of Site 1 - Former Base Landfill, January 19, 1989, Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-11
4-6	Potentiometric Surface Map of Site 1 - Former Base Landfill, August 16, 1991 Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-12

LIST OF FIGURES (CONTINUED)

FIGURE	TITLE	PAGE NO.
4-7	Locations of Interpreted Landfill Zone From the Surface E.M. Conductivity Survey at Site 1 - Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado	4-15
5-1	Field Activity Locations for Site 2 - Former Fire Training Area No. 1, Colorado Air National Guard, Buckley Field, Aurora, Colorado	5-4
6-1	Field Activities for Site 3 - Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado	6-4
6-2	Generalized Geologic Profile of Site 3 - Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado	6-7
6-3	Generalized Geologic Profile B-B' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil ($\mu\text{g/kg}$) at Site 3 - Former Fire Training Area No. 2, Colorado Air National Guard, Aurora, Colorado	6-9
6-4	Potentiometric Surface Contour Map of Site 3 - Former Fire Training Area No. 2, January 19, 1989, Colorado Air National Guard, Buckley Field, Aurora, Colorado	6-10
6-5	Soil-Gas Isoconcentration Contour Map of Total Hydrocarbons for Site 3 - Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado	6-11
7-1	Field Activities for Site 4 - Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado	7-4
7-2	Generalized Geologic Profile A-A' of Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado	7-7
7-3	Generalized Geologic Profile B-B' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil ($\mu\text{g/kg}$) at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Aurora, Colorado	7-8
7-4	Generalized Geologic Profile C-C' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil ($\mu\text{g/kg}$) at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Aurora, Colorado	7-9
7-5	Generalized Geologic Profile D-D' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil ($\mu\text{g/kg}$) at Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Aurora, Colorado	7-10
7-6	Potentiometric Surface Contour Map of Site 4 - Former Fire Training Area No. 3, January 19, 1989, Colorado Air National Guard, Buckley Field, Aurora, Colorado	7-12

LIST OF FIGURES (CONTINUED)

FIGURE	TITLE	PAGE NO.
7-7	Potentiometric Surface Contour Map of Site 4 - Former Fire Training Area No. 3, August 15, 1991, Colorado Air National Guard, Buckley Field, Aurora, Colorado	7-13
7-8	Soil-Gas Isoconcentration Contour Map of Total Hydrocarbons for Site 4 - Former Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado	7-14
8-1	Field Activities for Site 5 - Storm Drainage System, Colorado Air National Guard, Buckley Field, Aurora, Colorado	8-4
9-1	Field Activities for Site 6 - Former Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado	9-4
9-2	Generalized Geologic Profile A-A' of Site 6 - Former Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado	9-6

TABLE OF CONTENTS

TABLE OF APPENDICES (VOLUME II A - G)

APPENDIX A REMEDIAL INVESTIGATIONS WORK STUDIES

APPENDIX B PUBLIC HEALTH AND RISK ASSESSMENT

APPENDIX C SOIL BORING, MONITORING WELL LOGS AND COMPLETION FORMS, WELL
DEVELOPMENT FORMS, AND SAMPLING FORMS

APPENDIX D AQUIFER TEST DATA AND ANALYSIS

APPENDIX E GEOPHYSICAL SURVEY

APPENDIX F SOIL-GAS SURVEY RESULTS

APPENDIX G LABORATORY ANALYTICAL DATA

TABLE OF APPENDICES (VOLUME III H - K)

APPENDIX H CHEMICAL ANALYSIS QA/QC PROGRAM RESULTS

APPENDIX I GEOTECHNICAL LABORATORY RESULTS

APPENDIX J UNDERGROUND STORAGE TANK DATA COMPILATION

APPENDIX K BIOGRAPHIES OF KEY PERSONNEL

EXECUTIVE SUMMARY

This Remedial Investigation (RI) report describes field activities, presents and evaluates data, and provides recommendations for six sites at the Colorado Air National Guard, Buckley Air National Guard Base (ANGB), Aurora, Colorado. These six sites were identified as potential environmental problem sites during the Preliminary Assessment (Phase I Records Search), and initially studied during two previous Site Inspections (SIs; Phase II, Stage 1, Stage 2) for the National Guard Bureau (NGB) Installation and Restoration Program (IRP). The purpose of an SI is either to confirm or deny the existence of suspected environmental contamination at each site identified during the Preliminary Assessment.

RI activities were initiated in 1988 to define the extent of confirmed environmental contamination and further assess the associated potential risk to human health at six sites investigated in the Site Inspection (SI). At the conclusion of the 1988 RI, data gaps existed that required an additional phase of investigation activities to meet the objectives of the RI. These additional activities were conducted at three sites during the 1991 phase of the RI. This RI Report has incorporated all the findings from the RI addendum (1991).

The site numbering system used during the Installation Restoration Program (IRP) is based upon the ranking of sites from the results of the Hazard Assessment Rating Methodology (HARM), which is a preliminary estimate of the site's potential threat to human health or the environment. HARM scoring was performed during the Preliminary Assessment (PA) (Phase I - Records Search) at Buckley ANGB in August, 1982 and the sites were numbered according to their ranking as follows:

Site 1 - Former Training Area No. 2

Site 2 - Oil Pit

Site 3 - Former Base Landfill

Site 4 - Fire Training Area No. 3

Site 5 - Former Fire Training Area No. 1

Site 6 - Drainage Ditch

Site 7 - Former Sewage Treatment Plant

Site 8 - Army Aircraft Burial

During the subsequent Site Inspections (SI) these sites were renumbered and combined for unknown reasons. The following is a listing of the site number designations that are used in this current draft of the RI report:

Site 1 - Former Base Landfill and Oil Pit

Site 2 - Former Fire Training Area No. 1

Site 3 - Former Fire Training Area No. 2

Site 4 - Fire Training Area No. 3

Site 5 - Drainage Ditch

Site 6 - Former Sewage Treatment Plant

Site 7 - Army Aircraft Burial

The RI Part 1 field program was performed from early October 1988 through early January 1989, and consisted of the following data collection activities at six sites:

- Soil gas surveys (Sites 2, 3, and 4)
- Electromagnetic (EM) geophysical survey (Site 1)
- Drilling, soil sampling, and abandonment of soil borings (Sites 1, 3, 4, and 6)
- Drilling, soil sampling, installation, and groundwater sampling of monitoring wells (Sites 2, 3, 4, 6, and background)
- Sediment sampling (Sites 1, 5, and 6)
- Aquifer (slug) testing (Sites 1, 2, 3, 4, and background)
- Static groundwater measurement (Sites 1, 2, 3, 4, 6, and background).

A follow-on RI field program (RI Part 2) was performed from late July 1991 through late August 1991. This field work was a continuation of the previous IRP RI studies conducted by SAIC and was designed to fill in the data gaps from the RI Part 1 study. The RI Part 2 consisted of the following data collection activities at three sites:

- Drilling, soil sampling, and abandonment of soil borings (Sites 3 and 4)
- Drilling, soil sampling, installation, and groundwater sampling of monitoring wells (Sites 1, 4 and background)
- Static groundwater measurement (Site 1, 4, and background).

The following paragraphs describe and briefly discuss the results and conclusions at each of the six sites studied during this RI (Parts 1 and 2).

Site 1--The Former Base Landfill

The Former Base Landfill is located along Tollgate Creek in the southwestern portion of the Base. The landfill received Buckley municipal refuse from 1942 to 1982 and refuse from Lowry Air Force Base (AFB) during the early 1960s. Materials disposed of included building materials, paint cans, solvent containers, pesticide containers, municipal refuse, fuel tank sludges, and construction rubble. Waste was periodically burned to reduce waste volume. An oil pit also existed at this site but was taken out of service and backfilled with gravel in 1987. The pit reportedly measured about 10 feet by 10 feet and 15 feet deep. Oil was burned occasionally during the 1950s and disposal of solvents within the pit may have occurred.

Three soil samples (of the 18 soil samples that were analyzed at the site) showed the presence of low levels of petroleum hydrocarbon contamination. These contaminated samples were taken from a depth of 10 to 15 feet at locations adjacent to the former oil pit and Tollgate Creek. Sampling indicated that there has not been significant vertical contaminant migration within the soil, and that contamination within this soil is random. Groundwater samples showed limited evidence of site-related contamination. Sediment samples taken from the Tollgate Creek bed also showed no evidence of site-related contamination.

Because of various activities, including the 13 monitoring wells located at up-, cross-, and downgradient groundwater locations at the site, the drilling of three soil borings, and sampling of the stream sediments, the landfill has been adequately monitored to detect any major contamination problem. Results have shown no stream sediment contamination, low levels of apparently random, extremely limited subsurface soil contamination and minor groundwater contamination in monitoring well LFW-15. A baseline public health risk assessment indicated that there is no significant carcinogenic or noncarcinogenic risk associated with the presence of this limited soil and groundwater contamination at the site. However, since trichloroethene groundwater contamination is present in LFW-15 a long-term groundwater monitoring plan is proposed. The long-term monitoring plan would consist of sampling LFW-15 and the existing downgradient monitoring network (wells LFW-5, LFW-14, LFW-13, and LFW-8) in order to determine the potential for contaminant migration.

The variability of the stream sediment analyses does not eliminate the possibility of minor contamination. If the Department of Defense funding priorities permit, the sediment will be more adequately studied.

Site 2--Former Fire Training Area No. 1

Fire Training Area No. 1 is located in the vicinity of the Base Reservoir and consisted of an unlined and undiked burn area used for exercises during the late 1940s and early 1950s. Fuels burned were primarily nonspec AVGAS; however, the frequency of training exercises conducted at the site is unknown.

The soil-gas survey and analysis of soil samples do not indicate the presence of environmental contamination due to previous fire training exercises. No soil or groundwater contamination was detected within the hydraulically downgradient monitoring well.

Because of the data obtained from the downgradient monitoring well located at this site, the soil-gas survey, and two soil borings drilled during a previous study at a different suspected burn pit location, Site 2 has been adequately monitored to conclude that no major contamination is present. Because no soil or groundwater contamination has been located at either of the suspected burn pit locations, and since there has been an adequate amount of time since burn pit abandonment for natural biodegradation of any hydrocarbon contamination to occur, and the relatively short-term of operation (Site 2 operated for five years; Site 3, another former fire training area, was used for 22 years) - the site is not recommended for any immediate further action. It is recommended for further study by a direct push sampling technique. It is anticipated that this action will lead to the drafting of a decision document to remove the site from the IRP.

Site 3--Former Fire Training Area No. 2

Fire Training Area No. 2, located near the present air traffic control tower, was operated between 1950 and 1972. Nonspec fuels, including AVGAS and JP-4 jet fuel and, possibly, waste solvents, were burned during training exercises. Exercises were conducted about six times per month.

The soil-gas survey detected elevated (relative to background) concentrations of petroleum-related contamination within a radius of approximately 25 feet in the former burn pit area. Lower concentrations were detected in an irregular pattern up to 50 feet from the burn pit area. This pattern may be due to regrading and spreading of the soils surrounding the fire pit during abandonment, or to volatile contaminant migration through the soil gases. Volatile organic compounds were detected in one soil boring (F2B-6) located in the burn pit area above the 10-foot below land surface (BLS) depth. Deeper soil samples from this boring, as well as samples collected from the other four boreholes drilled within the former burn pit and soil samples collected during drilling of three monitoring wells, indicate that contaminants are probably not migrating deeper into the soil. No site-related contamination was found within groundwater samples taken at the site.

The results of the soil boring (F2B-6) drilled through the center of the burn pit (RI Part 1) show that minor soil contamination is limited to 8 feet or less in depth, which is well above the 25-foot depth of the potentiometric water surface. Subsurface soil samples collected from the four soil borings drilled within the burn pit during the RI Part 2 did not confirm the minor contamination detected in F2B-6. Clay layers exist above the groundwater, creating confined aquifer conditions beneath the site and protecting the groundwater from the downward migration of the surficial contamination. Because of these clay layers, groundwater contamination is unlikely but not impossible. Therefore, it is recommended that a new monitoring well be installed as directed by the latest groundwater flow data. A baseline public-health evaluation indicates that there is no significant carcinogenic or noncarcinogenic risk associated with the soil contamination at the site. Therefore, any further action at this site will have a low priority in the Department of Defense relative risk program.

Site 4--Fire Training Area No. 3

Fire Training Area No. 3 is located west of Building 801 and has been in operation since 1972. Current fire-training procedures are to saturate the surface with water to reduce infiltration, and ignite approximately 150 gallons of nonspec JP-4 jet fuel poured on the pad. Twenty-four exercises are conducted annually. Approximately 50 to 70% of the fuel is burned off during the exercise (Simons, Li, & Associates, Inc. 1982; Butler 1988).

The soil-gas survey data indicate the presence of a 170 foot by 260 foot area of petroleum-related hydrocarbon contamination. The contamination is centered in the burn pit area, with the long axis trending south in the direction of the waste fuel storage area at the site. The area of soil contamination within the burn area was further defined by five soil borings. All five borings drilled within the burn area showed high levels of volatile and semivolatile contamination at the surface, which decreased with depth. Results from the laboratory analysis of borehole soil samples showed that soil contamination extended to 22.0 ft BLS in F3B-12. However, the on-site GC results showed that soil contamination had extended to 41.5 and 36.5 ft BLS in F3B-12 and F3B-14, respectively. Analysis of samples from soil borings outside the burn area (F3B-7 and F3B-15) showed low levels of petroleum hydrocarbon contamination present only to a depth of 2 ft (F3B-7). Deeper samples within both borings showed no site-related contamination. The monitoring well borehole (F3W-4) installed adjacent to the burn pit showed elevated levels of petroleum related contamination to a depth of 40 ft. Other monitoring well borehole samples showed no evidence of any site-related contamination.

Very limited site contamination was detected in the groundwater at the site. Estimated concentrations (below the sample quantitation limit but greater than zero) of organic compounds were detected in F3W-8. Inorganic compounds were detected, but were at levels consistent with naturally occurring background levels.

The results of the five soil borings drilled within the burn area clearly show that soil contamination is present to 22.0 ft BLS. A baseline public health evaluation indicates that there is no significant carcinogenic or noncarcinogenic risk associated with the soil contamination at the site. However, the mean levels of the contaminants used in the risk calculation also include those soil samples taken from outside the burn area (F3B-7 and F3B-15). Therefore, a nontime-critical source removal action for the soil within the burn pit is recommended for Site 4.

Site 5--Storm Drainage System

Between 1942 and 1982, aircraft were washed and painted on the aircraft parking apron south of Building 801. Fuels, cleaning compounds, ethylene glycol, paints, and strippers were used in this process (Simons, Li, & Associates, Inc. 1982). Stormwater drains from this area to the southwest portion of the apron, and then to a storm drainage ditch which in turn drains into Tollgate Creek.

Low levels of volatile organic compounds related to petroleum were detected at only one of the six sediment sampling locations situated immediately to the southwest of the apron. These levels of

volatile organic compounds are probably a result of storm runoff from the parking apron. Field reconnaissance found no widespread areas which appeared to have been affected by any contamination. No sampling of the outfall was performed and that data gap does exist.

A baseline public health evaluation showed no significant risk associated with the contaminated soil. Therefore, no further immediate action is necessary at this site. The drafting of a decision document should be await the sampling of the alluvium at the discharge of the ditch.

Site 6--Former Sewage Treatment Plant

The Sewage Treatment Plant was in operation from 1942 to 1978 and was subject to occasional "slugs" of chemical wastes, including water containing petroleum products, organic solvents, trace metals, and pesticides (Dames & Moore 1987). Because of their permeable bottoms, the trickling filters and sludge drying beds at the site presented a potential route of contamination through leakage and infiltration to groundwater.

Elevated levels of chromium, lead, mercury, silver, and thallium were detected at the five-foot level in two soil borings located within the sludge drying beds. No site-related contamination was found in the deeper samples within these boreholes or within a borehole drilled adjacent to the trickling filters and the digester. No site-related contamination was detected in the groundwater.

Soil boring data clearly show that contamination within the sludge drying beds are limited to soils at the 5-foot depth, well above the approximate 50-foot depth of the potentiometric groundwater surface. Therefore, this site has been adequately monitored to detect the extent of contamination at the site and affected media. A baseline public health evaluation indicates that there is no significant risk associated with metal soil contamination in the sludge drying beds. Therefore, no further action is recommended at this site and a decision document should be prepared in order to eliminate the site from the IRP.

1.0 INTRODUCTION

The U.S. Department of Defense (DOD) initiated the Installation Restoration Program (IRP) to identify, evaluate, and remediate as necessary suspected environmental problems associated with past waste disposal, handling, and spill sites on DOD facilities.

The first step in the IRP, the Preliminary Assessment (Phase I-Records Search), was completed at Buckley Field (herein after also referred to as the Base) in 1982 (Simons, Li, & Associates, Inc. 1982). This study identified six study sites which warranted further investigation; these are described in detail in Section 1.1.1. The next step in the IRP was initiated during two subsequent Site Inspections (SIs; Phase II, Stages 1 and 2-Confirmation/Quantification) in 1986 and 1987 (Dames & Moore 1986; Dames & Moore 1987). The objective of an SI is to acquire the necessary data to either confirm or deny the existence of suspected environmental contamination at each identified site of concern and to preliminarily assess the potential risks to human health, welfare, and the environment. A summarization of the results of these studies is presented in each site discussion. Table 1-1 outlines the chronology, terminology used, and contractors involved in these IRP studies.

The site numbering system used during the Installation Restoration Program (IRP) is based upon the ranking of sites from the results of the Hazard Assessment Rating Methodology (HARM) which is a preliminary estimate of the site's potential threat to human health or the environment. HARM scoring was performed during the Preliminary Assessment (PA) (a.k.a. Phase I - Records Search) at Buckley ANGB in August, 1982 and the sites were numbered according to their ranking as follows:

Site 1 - Former Training Area No. 2

Site 2 - Oil Pit

Site 3 - Former Base Landfill

Site 4 - Fire Training Area No. 3

Site 5 - Former Fire Training Area No. 1

Site 6 - Drainage Ditch

Site 7 - Former Sewage Treatment Plant

Site 8 - Army Aircraft Burial

TABLE 1-1. REFERENCE CHART FOR THE CHRONOLOGY, PURPOSE AND TERMINOLOGY USED IN IRP STUDIES
CONDUCTED AT COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

Air National Guard Document Title	CERCLA Terminology Equivalent	Purpose of Study and Result	Date Completed	Contractor
Phase I - Records Search	Preliminary Assessment	Identify sites which may adversely impact public health or the environment. Identified seven sites.	August 82	Simons, Li & Associates
Phase II - Stage 1, Part 1	Site Inspection	Determine if sites adversely impact public health or environment at five sites. Results inconclusive.	May 86	Dames and Moore
Phase II - Stage 1, Part 2	Site Inspection	Determine if sites adversely impact public health or environment at the two remaining sites. One site determined to pose no adverse impact. Other results inconclusive.	May 87	Dames and Moore
Remedial Investigation	Site Inspection and Remedial Investigation	Determine if six remaining sites adversely impact public health or environment. If it is determined that there is adverse impact, determine the magnitude, extent, and character of the contamination at the site.	Ongoing	Science Applications International Corporation

CERCLA - Comprehensive Environmental Response, Compensation and Liability Act

1289/BKLY/2

During the subsequent Site Inspections (SI) these sites were renumbered and combined for unknown reasons. The following is a listing of the site number designations that are used in this current draft of the RI report:

Site 1 - Former Base Landfill and Oil Pit

Site 2 - Former Fire Training Area No. 1

Site 3 - Former Fire Training Area No. 2

Site 4 - Fire Training Area No. 3

Site 5 - Drainage Ditch

Site 6 - Former Sewage Treatment Plant

Site 7 - Army Aircraft Burial

This report documents the RI Part 1 (late 1988 through early 1989) and the RI Part 2 (late July through late August 1991) performed by SAIC at Buckley field. The objective of these studies is to fill in data gaps from previous studies in order to confirm or deny the presence of contamination; determine the character, magnitude, and extent of contamination; and to determine the risk to human health posed by any contamination at the sites in question. As a result, the RI phase of the IRP will conclude with this study, and the sites would either be eliminated from future study or moved into the Feasibility Study (FS) phase of the IRP which would evaluate the proper remedial action to clean up any significantly contaminated sites.

1.1 SITE BACKGROUND INFORMATION AND PREVIOUS STUDIES

As discussed above, several preceding IRP studies have been performed at Buckley Field (Table 1-1). The following are brief descriptions of these studies. Detailed discussions of these results appear in each site discussion in later sections.

1.1.1 Installation Restoration Program Phase I Records Search (Preliminary Assessment)

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley Field and to assess the potential for contaminant presence and migration. This phase consisted primarily of inter-views and record review.

From this records search, six sites were judged to present a moderate potential for mobilization and migration of contaminants and were recommended for IRP Phase II investigations. The sites, listed in order of priority and shown in Figure 1-1, are Fire Training Area (FTA) No. 2, the Former Oil Pit, Base Dump (landfill), FTA No. 3, FTA No. 1, and the Storm Drainage System near the main aircraft apron. Two additional sites--the sludge drying beds at the sewage treatment plant and an aircraft burial site near Former Fire Training Area No. 2--were judged

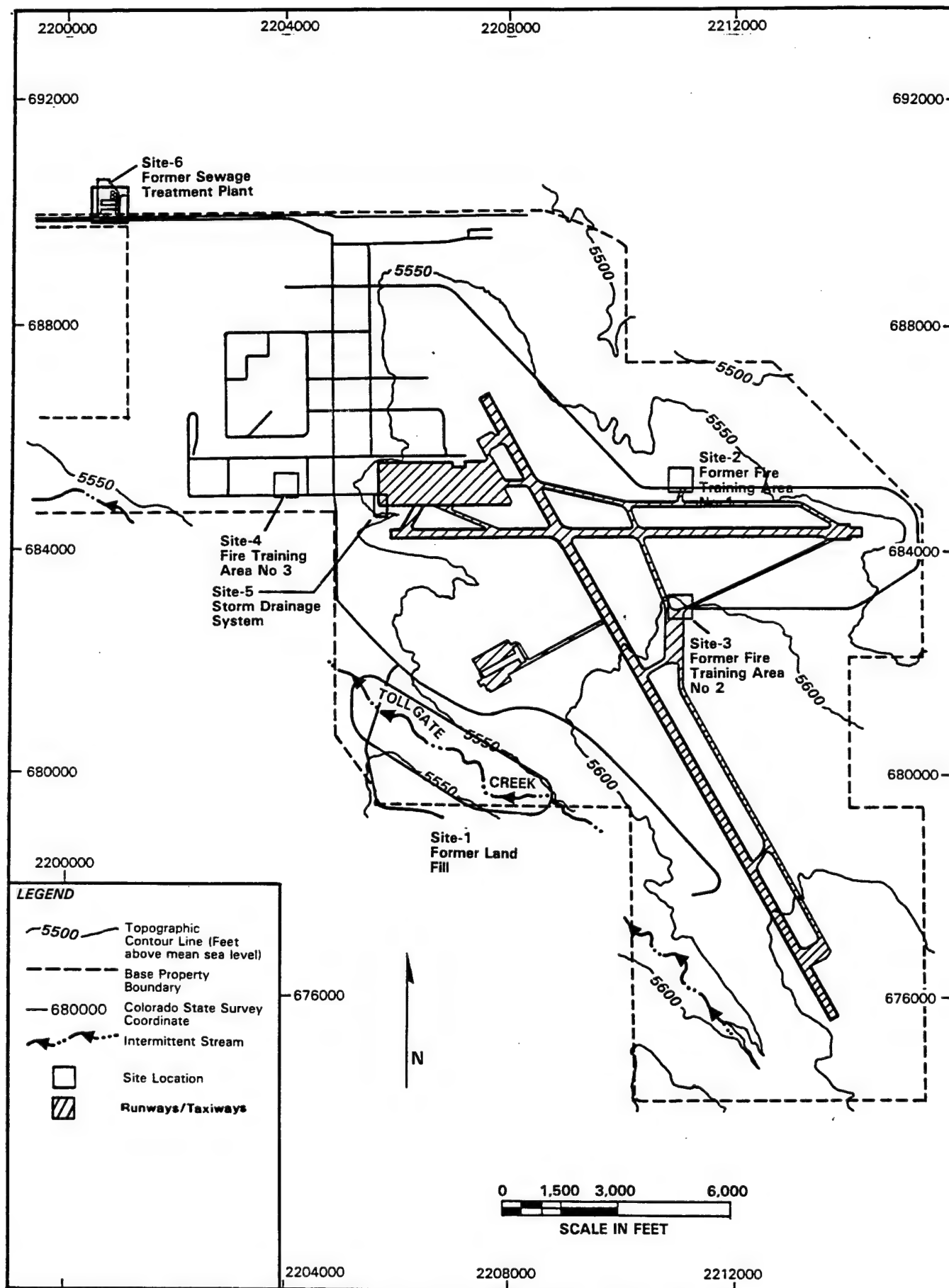


Figure 1-1 Site Location Map for Colorado Air National Guard, Buckley Field, Aurora, Colorado

to have a low potential for contaminant migration, but also were recommended to be included in Phase II investigations. More complete discussion of Phase I activities is presented in "Installation Restoration Program, Phase I: Records Search, Buckley Air National Guard Base, Aurora, Colorado" (Simons, Li, & Associates, Inc. 1982). The following site descriptions are based upon the findings of this Phase I study.

Site 1--Former Base Landfill and Former Oil Pit

The Former Base Landfill received Buckley municipal refuse from 1942 to 1982 and refuse from Lowry AFB during the early 1960s. Trench-and-fill methods were used. Between 1947 and 1959 (during Navy occupation), and perhaps later, the landfill was burned periodically, probably using waste oil and other flammables to aid combustion. Materials disposed of in the Former Base Landfill included building materials, paint cans, solvent containers, pesticide containers, municipal refuse, fuel tank sludges, and construction rubble.

The Former Oil Pit was taken out of service and backfilled with gravel in 1987. The pit reportedly measured about 10 ft by 10 ft and 15 ft deep, and was enclosed at the sides and bottom by continuously-poured concrete. Contents of the Former Oil Pit were burned occasionally during the 1950s. Specific information about other materials that may have been placed in the pit is unavailable; however, disposal of solvents may have occurred. The depth to groundwater at this location has been estimated as less than 20 ft below land surface.

Site 2--Former Fire Training Area No. 1

The precise location of FTA No. 1 has been uncertain. Previous studies suggested that the site was located south and west of the surface reservoir located in the northeast corner of the base. Interviews with the Base Fire Chief during preparation of the work plan for this RI effort suggest, however, that the site is located southeast of the reservoir, which is used as water storage for fire fighting and for recreational fishing (Simons, Li, & Associates, Inc. 1982; Butler 1988). FTA No. 1 was unlined and undiked and used as an AVGAS burning site during the late 1940s and early 1950s. The frequency of training exercises at the site is unknown. Residual flammable materials may be present on the site. A "firing-in" range for alignment of aircraft guns once occupied the site; an aircraft engine test facility is currently located there.

Site 3--Former Fire Training Area No. 2

The Base Fire Chief reports that FTA No. 2 was located and was used between 1950 and 1972. The site is reportedly unlined and undiked and is within 2000 ft of Base Well No. 4, a potable water-supply well. Hazardous materials including AVGAS and JP-4 jet fuel and, possibly, waste solvents were burned. A protein-based foam (which consisted primarily of ox blood) was used to extinguish fires (Butler 1988). Exercises were conducted about six times monthly. A hangar for small aircraft has been constructed on or immediately adjacent to the location and extensive concrete and asphalt pavements are in place over much of the site.

Site 4--Fire Training Area No. 3

FTA No. 3 is located west of Building 801; it has been in operation since 1972. Current fire-training procedures are to saturate the surface with water to reduce infiltration, ignite approximately 150 gal of water-contaminated JP-4 jet fuel spread on the pad, and extinguish the fire with water and 6% (currently 3%) aqueous film-forming foam (AFFF). Twenty-four exercises are conducted annually using about 400 gal of AFFF. Approximately 50 to 70% of the fuel is burned (Simons, Li, & Associates, Inc. 1982; Butler 1988).

Site 5--Storm Drainage System

The Storm Drainage System, which serves the aircraft apron and associated hangers and buildings, consists of a system of pipes, culverts, and open ditches. The drainage system is discharged to East Tollgate Creek. Between 1942 and 1982, aircraft were washed and painted on the apron south of Building 801. The apron was washed with water that either infiltrated or flowed off northeastward to a drainage ditch, which in turn flowed off-base. Fuels, cleaning compounds, ethylene glycol, paints, and strippers were used in this area (Simons, Li, & Associates, Inc. 1982).

Note: Later inspection of topographic maps indicated that surface water flow is toward the southwest not the northeast. Therefore, the focus of the RI study centered around the soils to the southwest of the aircraft parking apron and not the drainage ditch which runs north of the site.

Site 6--Former Based Sewage Treatment Plant

The Sewage Treatment Plant was in operation from 1942 to 1978 when the sludge digester roof collapsed and the plant was closed. Reportedly, the plant was subject to occasional "slugs" of chemical wastes, including water containing petroleum products, organic solvents, trace metals, and pesticides (Dames & Moore 1987).

The plant consisted of bar screens, a primary clarifier, a trickling filter, a sludge digester, chlorine contact chambers, and sludge drying beds. Treated effluent from the plant was discharged to Sand Creek. The sludge drying beds, which were rarely cleaned, were designed with a filtrate collection system; however, the clay tiles comprising this system collapsed early in its life (Simons, Li, & Associates, Inc. 1982). Due to their permeable bottoms, the trickling filters and sludge drying beds presented a potential route of contamination via leakage and infiltration to groundwater.

1.1.2 Site Investigations (SIs)

IRP Phase II, Stage 1, Part 1, Confirmation/Quantification (Site Inspection)

Field investigations were conducted at five of the sites--the Former Base Landfill and Former Oil Pit (combined into one site), FTA Nos. 1 through 3, and the Storm Drainage System near the main aircraft apron. The objectives of the Phase II, Stage 1 were to:

- Determine the presence or absence of contamination resulting from waste disposal practices;
- Provide estimates of the magnitude and extent of contamination, should contamination be found;
- Identify significant health and environmental hazards generated by migrating pollutants; and
- Identify any additional investigations and their attendant costs necessary to properly evaluate the magnitude, extent, and direction of movement of discovered contaminants.

Activities included drilling, sampling, and logging of four monitoring wells and nine soil borings. Water levels were measured for each new well, and chemical analyses of soil and water samples were performed. All sites were recommended for further investigation. Recommendations were to:

- Resample for cadmium presence and distribution
- Perform a geophysical resistivity survey
- Install four new wells for sampling at the Landfill
- Install and sample three new wells at FTA No. 3
- Install one downgradient well at FTA No. 1, FTA No. 2 and the Storm Drainage System.

A complete description of results of IRP Phase II, Stage 1, Part 1 activities are presented in "Installation Restoration Program, Phase II-Confirmation/Quantification Stage 1, Buckley Air National Guard Base" (Dames & Moore 1986).

IRP Phase II, Stage 1, Part 2, Confirmation/Quantification (Site Inspection)

A field investigation was conducted at the Sewage Treatment Plant and an attempt was made to locate an Army aircraft burial site. This burial site was highlighted during the IRP Phase I-Records Search (Preliminary Assessment) as with only a minimal potential for contaminant migration. The aircraft burial site (Site 7) was not located during a limited magnetometer and metal locator survey and was recommended to be removed from further IRP consideration. Activities at Former Sewage Treatment Plant included the installation and sampling of three monitoring wells and soil borings.

Recommendations were to resample the wells during times of higher groundwater elevations and analyze samples to determine whether the low levels of contamination detected can be substantiated. Results of IRP Phase II, Stage 1, Part 2 (Site Inspection) activities are presented in "Installation Restoration Program Phase II-Confirmation/Quantification Stage 1, Buckley Air National Guard Base, October 16, 1985 to November 5, 1985" (Dames & Moore 1987).

1.2 OVERVIEW OF REPORT

This report initially provides a brief discussion of the RI activities that have been performed to date, data analysis methods, the environmental setting, and background environmental chemistry. This lays a framework for the following sections, which discuss the history, previous findings, RI field work, results, and conclusions and recommendations for each site on a site by site basis. Appendices located in a separate volume provide detailed discussions of field activity and data analysis procedures, raw data, and other supporting information. The following is an outline of the format of the remainder of the report.

- 2.0 Remedial Investigation Activities and Approach-presents an overview of the procedures employed during the field activities and data analyses conducted during the Remedial Investigation (RI Parts 1 and 2).
- 3.0 Regional Environmental Setting-presents a discussion of regional and basewide hydrogeology and the chemical characteristics of the soil and groundwater located in the area.
- 4.0 Site 1: Former Base Landfill and Former Oil Pit-provides descriptions of the site and the environmental setting, previous work, latest RI activities, groundwater, soil and sediment sampling results, risk assessment, and conclusions and recommendations for future IRP activities.
- 5.0 Site 2: Former Fire Training Area #1-provides descriptions of the site and the environmental setting, previous work, latest RI activities, groundwater, soil and sediment sampling results, risk assessment, and conclusions and recommendations for future IRP activities.

- 6.0 Site 3: Former Fire Training Area #2-provides descriptions of the site and the environmental setting, previous work, latest RI activities, groundwater, soil and sediment sampling results, risk assessment, and conclusions and recommendations for future IRP activities.
- 7.0 Site 4: Fire Training Area #3-provides descriptions of the site and the environmental setting, previous work, latest RI activities, groundwater, soil and sediment sampling results, risk assessment, and conclusions and recommendations for future IRP activities.
- 8.0 Site 5: Drainage Ditch-provides descriptions of the site and the environmental setting, previous work, latest RI activities, groundwater, soil and sediment sampling results, risk assessment, and conclusions and recommendations for future IRP activities.
- 9.0 Site 6: Former Sewage Treatment Plant-provides descriptions of the site and the environmental setting, previous work, latest RI activities, groundwater, soil and sediment sampling results, risk assessment, and conclusions and recommendations for future IRP activities.

2.0 REMEDIAL INVESTIGATION ACTIVITIES AND APPROACH

This section provides the objectives, summary of the methods, and rationale for the Remedial Investigation (RI Parts 1 and 2) program that was implemented by Science Applications International Corporation (SAIC) at the Colorado Air National Guard, Buckley Air National Guard Base (ANGB).

The RI focused on six sites which were outlined in a Preliminary Assessment (Phase I-Records Search) (Simon, Li, and Associates, Inc. 1982) and studied during two earlier Site Inspections (Phase II Stage 1, Parts 1 and 2--Confirmation/Quantification; Dames & Moore 1986 and 1987). These six sites are:

- Site 1--Former Base Landfill and Former Oil Pit
- Site 2--Former Fire Training Area No. 1
- Site 3--Former Fire Training Area No. 2
- Site 4--Fire Training Area No. 3
- Site 5--Storm Drainage System
- Site 6--Former Base Sewage Treatment Plant.

The objectives of the RI activities were to:

- Determine if contamination of the various environmental media at each of the sites is present
- Identify the source(s) and nature of any contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risks any present contamination pose to public health, thereby determining the need for remedial actions.

2.1 FIELD PROGRAM ACTIVITIES AND PROCEDURES

The RI Part 1 field program at the Base, which was performed from early October 1988 through early January 1989, consisted of the following data collection activities at six sites:

- Soil-gas surveys (Sites 2, 3, and 4)
- Electromagnetic (EM) geophysical survey (Site 1)
- Drilling, soil sampling, and abandonment of soil borings (Sites 1, 3, 4, and 6)

- Drilling, soil sampling, installation, and groundwater sampling of monitoring wells (Sites 2, 3, 4, 6, and background)
- Sediment sampling (Sites 1, 5, and 6)
- Aquifer (slug) testing (Sites 1, 2, 3, 4, and background)
- Static groundwater measurement (Sites 1, 2, 3, 4, 6, and background).

A follow-on RI field program (RI Part 2) was performed from late July 1991 through late August 1991. This field work was a continuation of the previous IRP studies conducted by SAIC and was designed to fill in the data gaps from the RI Part 1. The RI Part 2 consisted of the following data collection activities at three sites:

- Drilling, soil sampling, and abandonment of soil borings (Sites 3 and 4)
- Drilling, soil sampling, installation, and groundwater sampling of monitoring wells (Sites 1, 4, and background)
- Static groundwater measurement (Sites 1, 4, and background).

The following are summaries of in-depth descriptions of the field activities which are located in Appendix A. The following subsections describe the procedures and underlying purposes of these data collection activities which were taken in order to maintain the validity of the RI work performed at Buckley ANGB.

2.1.1 Soil-Gas Surveys and Procedures

Soil-gas surveys were conducted at three sites (Sites 2, 3, and 4) during the RI part 1 at Buckley ANGB. By identifying and quantifying volatile organic compounds (VOCs) in the vadose zone, the purpose of soil-gas surveying is to determine the presence of soil and/or groundwater contamination. At Buckley sites, this survey was used to confirm the suspected presence of contaminants, define the horizontal magnitude and extent of contamination, and locate the probable source(s) of any contamination found at the surveyed sites. The survey results also served to assist in the location of groundwater monitoring wells.

Based on knowledge of the materials that are or were stored or used at the sites, samples were analyzed specifically in the field using a laboratory gas chromatograph (GC), which was portable but fully equipped, checked, and calibrated prior to use in the field. The samples were collected and immediately analyzed in the field with the GC for several organic compounds which were suspected of being present at sites surveyed:

- Total petroleum hydrocarbons
- Total xylenes

- Ethylbenzene
- Benzene
- Toluene
- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- Carbon Tetrachloride
- 1,1,1 Trichloroethane (TCA).

Samples were collected by hydraulically pushing a hollow steel probe 3 to 6 ft into the ground and evacuating the sample with a vacuum pump. Soil-gas samples were collected by inserting a syringe needle through a silicone evacuation line, which had been inserted into the steel probe. Each sample was collected for immediate analysis by the GC. Following the collection of each sample, the probe was extracted from the ground.

2.1.2 Surface Electromagnetic Conductivity Survey

A surface electromagnetic (EM) conductivity survey was conducted during the RI Part 1 at Buckley ANGB with the objective of locating landfill site boundaries. The survey was conducted at Site 1 (Former Base Landfill).

EM conductivity surveying is a method of obtaining subsurface information by inducing an electric source field into the earth from a surface transmitter coil. The theory developed for EM surveying assumes the ground to be homogeneous, isotropic, and semi-infinite; therefore, all surface conductivity measurements are referred to as "apparent conductivity" to discriminate between ground conductivity and measured conductivity (which reflects the cumulative response of subsurface "conductors"). Lateral changes in the electric properties of subsurface materials cause variations or anomalies in the apparent conductivity. These anomalies are used to interpret subsurface structure. The conductivity of soils or rocks is particularly sensitive to water content and dissolved salts or ions. Accordingly, dry sands and gravels, and massive rock formations have low conductivity, while saturated sands and gravels, most clays, and other materials with high ion content have high conductivity. Landfill areas and buried metal objects often have different conductivity than surrounding terrain, and therefore produce anomalies.

2.1.3 Monitoring Well Drilling, Installation, and Sampling

Monitoring wells were drilled and installed during the RI Part 1 at four sites (Sites 2, 3, 4, and 6) at Buckley ANGB from late October through early December 1988. Data collected during the monitoring well drilling and sampling process provide information on contaminant presence, characteristics, and movement in soil and groundwater in the site area. Generally, one monitoring

well at each site was installed upgradient of the potentially contaminated area(s), while the remainder of the monitoring wells at each site were installed downgradient to cross-gradient of the potentially contaminated area(s). Groundwater flow directions were determined based upon the hypothesis that the water table generally mimics surface topography. At Sites 3 and 4 - Fire Training Areas 2 and 3 where the topography was flat, a brief leveling survey was conducted after two wells were installed to determine the component of groundwater flow between the two wells.

Although soil sampling was continuous, chemical samples were only collected at 5-ft intervals, and only a fraction of these soil samples were sent to an off-site environmental laboratory for in-depth analyses. The remainder of the 5-ft samples were archived at SAIC's Environmental Chemistry Laboratory. The parameters for these analyses were selected on the basis of the potential contaminants suspected at each site. Analytical methods sample preservation guidelines and other pertinent chemical laboratory information are presented in Tables 2-1a and 2-2a, respectively. Sample selection was based upon HNu results, proximity to the groundwater table, and depth of the suspected contaminant source. Generally, the most contaminated samples were sent to the laboratory; however, if samples showed similar or no contamination based upon HNu results, a near-surface sample, the sample just above the water table, and the first sample below the water table were sent to the laboratory. Results of all RI Part 1 chemical analyses are presented in Appendix G, Laboratory Analytical Data. Additionally, several monitoring well boreholes were analyzed for a set of geotechnical parameters, the results of which are located in Appendix I. Generally, samples were collected in the different lithologies within each sampled borehole to enable a full geotechnical characterization of all the strata encountered.

Monitoring well completion forms (schematics) and logs which describe individual wells installed during the RI Part 1 are presented in Appendix C. The depth of each monitoring well boring was generally 10-15 ft below the water table. However, where locally confined aquifer conditions existed or where the water bearing zone was not clear, actual well depths were set to assure the integrity and usefulness of the completed well.

Prior to well monitoring and groundwater sampling, each well was purged of at least three to five saturated borehole volumes. Most of the wells on the Base were poor producers of water due to the small saturated thickness and fine-grained nature of the aquifer; purging required as long as 8 hr in many cases. Within 24 hours of the purging, groundwater was sampled for the parameters listed in Table 2-1a (RI Part 1).

Monitoring wells were drilled and installed during the RI Part 2 at two sites (Sites 1 and 4) from late July through mid-August 1991. Drilling was performed by Layne Environmental Services of Denver, Colorado under the direction of SAIC field personnel. All monitoring wells installed during the RI Part 2 were drilled with hollow-stem augers using a CME-750 ATV drill rig.

The rationale for the additional (RI Part 2) monitoring wells at the Former Base Landfill (Site 1) was to check for potential contamination in the groundwater emanating from two landfill anomalies identified by an electromagnetic conductivity survey done during the RI Part 1. At Fire Training Area No. 3 (Site 4), additional monitoring wells were required to check for potential contaminant migration downgradient of the source area. Monitoring wells installed at Site 4 during the RI Part 1 were not located directly downgradient of the source area (burn pit).

TABLE 2-1a. SUMMARY OF METHODS FOR ANALYSIS OF SOIL AND WATER SAMPLE
 COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
 REMEDIAL INVESTIGATION: PART 1

Parameter	SOIL AND SEDIMENT SAMPLES			WATER SAMPLES		
	Analytical Method ^a	Detection Limit ^b	Reporting Units ^c	Analytical Method ^a	Detection Limit ^b	Reporting Units ^d
<u>Organics</u>						
Purgeable Organics	SW-8240	c	µg/kg	SW-8240	c	µg/l
Extractable Organics	SW-3550/8270	d	µg/kg	SW-3510/8270	d	µg/l
Organochlorine Pesticides	SW-3550/8080	e	µg/kg	SW-3510/8080	e	µg/l
Chlorinated Herbicides	SW-8150	f	µg/kg	SW-8150	f	µg/l
<u>Inorganics</u>						
Percent Moisture	E-160.3	0.1	%	—	—	—
Priority Pollutant Metals	SW-3050/6010	g	mg/kg	SW-3005/6010	g	mg/l
Arsenic	SW-3050/7060	0.5	mg/kg	SW-3020/7060	0.001	mg/l
Mercury	SW-7471	1.0	mg/kg	SW-7470	0.005	mg/l
Selenium	SW-3050/7740	1.0	mg/kg	SW-3020/7746	0.001	mg/l
Lead	SW-3050/6010	0.5	mg/kg	SW-3020/7421	0.002	mg/l
Antimony	SW-3005/7041	1.0	mg/kg	SW-3005/7041	0.03	mg/l
Thallium	SW-3020/7841	2.0	mg/kg	SW-3020/7841	0.2	mg/l
<u>Miscellaneous</u>						
<u>Inorganics</u>						
Common Cations	—	—	—	SW-3005/6010	g	mg/l
Common Anions	—	—	—	A429	h	mg/l
Kjeldahl Nitrogen	—	—	—	E351.4	0.05	wt%

* The methods cited are from the following sources:

"A" Methods Standard Methods for the Examination of Water Wastewater, 16th Edition (American Public Health Association 1985)

"SW" Methods Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Third Edition (USEPA 1986)

"E" Methods Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory (EPA 1983)

^b The detection limits presented represent those established by the analytical method indicated.

^c Purgeable organics in water and soil/sediment samples using Method SW-8240. Sample PQLs are highly matrix-dependent. The PQLs are provided for guidance and may not always be achievable. PQLs are established for a wet-weight basis and will be corrected for percent moisture in soils or sediments when reporting PQLs for those matrices. Detection will usually be at or below the values specified.

^d Extractable organics in water and soil/sediment samples using Method SW-8270. PQLs listed for silt/sediment are based on wet-weight. Normally data is reported on a dry weight basis; therefore PQLs will be higher based on the percent moisture in each sample. This is based on a 30-g sample of a low-level soil/sediment. Since PQLs are highly matrix-dependent, the PQLs are provided for guidance and may not always be achievable.

^e Organochlorine pesticides and polychlorinated biphenyls in water and soil/sediment samples using Method SW-3550/8080. PQLs listed below are based on wet-weight for soil/sediment samples. The final results of these samples will be reported on a dry-weight basis; therefore, PQLs will be higher depending on the percent moisture in each aliquot. Since PQLs are highly matrix-dependent, the detection limits listed below are provided for guidance only and may not always be achievable.

^f Chlorinated herbicides in water and soil/sediment samples using Method SW8150. PQLs listed below are based on wet-weight for solid samples (uncorrected for percent moisture). The final results of these matrices will be reported on a dry-weight basis; therefore, PQLs will be higher depending on the percent moisture in each aliquot. Since PQLs are highly matrix-dependent, the detection limits listed below are provided for guidance only and may not always be achievable.

^g Metals in water and soil/sediment samples using Method SW6010. Limits of detection are based on laboratory detection limits or Practical Quantitation Limits (PQLs) as defined in the specific analytical method. The detection limits are given as a guide for an instrument limit. The actual method detection limits are sample dependent and may vary as the sample matrix varies.

TABLE 2-2a. SUMMARY OF SAMPLE CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES OF WATER AND SOIL SAMPLES ACCORDING TO MEASUREMENT, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

MEDIA MEASUREMENT	CONTAINER TYPE	PRESERVATIVE	HOLDING TIME
AQUEOUS SAMPLES			
<u>Organics</u>			
Purgeable Organics	Four 40-ml glass vials*	HCl to pH < 2, 4°C	14 days
Extractable Organics	Three 1.0-l glass bottles*	4°C	7 days-extraction, 40 days-analysis
Organochlorine Pesticides	Three 1.0-l glass bottles*	4°C	7 days-extraction, 40 days-analysis
Chlorinated Herbicides	Three 1.0-l glass bottles*	4°C	7 days-extraction, 40 days-analysis
<u>Inorganics</u>			
Priority Pollutant Metals	One 500-ml plastic bottle	HNO ₃ to pH < 2	6 months
Arsenic, Lead, Selenium	One 500-ml plastic bottle	HNO ₃ to pH < 2	6 months
Mercury	One 500-ml plastic bottle	HNO ₃ to pH < 2	28 days
<u>Miscellaneous Inorganics</u>			
Common Anions	One 1.0-l plastic bottle*	H ₂ SO ₄ to pH < 2, 4°C	28 days
SOIL AND SEDIMENT SAMPLES			
<u>Organics</u>			
Purgeable Organics	8 oz. widemouth glass jar*	4°C	14 days
Extractable Organics	16 oz. widemouth glass jar*	4°C	14 days-extraction, 40 days-analysis
Organochlorine Pesticides	8 oz. widemouth glass jar*	4°C	14 days-extraction, 40 days-analysis
Chlorinated Herbicides	8 oz. widemouth glass jar*	4°C	14 days-extraction, 40 days-analysis
<u>Inorganics</u>			
Priority Pollutant Metals	16 oz. widemouth glass jar	4°C	6 months
Arsenic	16 oz. widemouth glass jar	4°C	6 months
Mercury	16 oz. widemouth glass jar	4°C	28 days
Selenium	16 oz. widemouth glass jar	4°C	6 months

*Teflon-lined black phenolic screw-top cap

1289/BKLY/6

Ten-inch diameter boreholes were drilled for monitoring wells installed during the RI Part 2. Soil samples were collected from monitoring well boreholes at 5-ft intervals using split-spoons and 6-inch stainless-steel inserts. During the drilling each soil sample was screened on-site by Environmental Chemistry Services (ECS) using a gas chromatograph. The on-site screening was conducted to reduce the number of samples sent to the laboratory (NET Pacific) for in-depth analysis.

Soil samples collected during the RI Part 2 were screened on-site using a Shimadzu 8A GC with FID and PID detectors and a Supelco VOCOL 30m x 0.53mm I.D. column (modified method SW-8020). Ten grams of each sample was weighed into a 40 ml VOA bottle with a teflon septum. An equal portion of organic free water (10 mls) and 5 µl of internal standard (trifluorotoluene) were added. The bottle was then heated in a 90 degree water bath for 5 minutes, and 500 µl of the headspace gas withdrawn with a gas tight syringe and injected into the gas chromatograph. Prior to analyzing the soil samples, the instrument was calibrated with three standard concentrations. The soil samples were analyzed for toluene, ethylbenzene, xylene, methylene chloride and TCE. Results of the on-site GC screening are presented in Appendix G-1. Because of on-site GC screening no soil samples from monitoring well boreholes were sent to NET Pacific for in-depth analysis.

Monitoring well boreholes were drilled to a depth of seven to twelve feet below the water table. The water table was located by measuring the water level inside the hollow-stem augers. After the total borehole depth was reached, well installation commenced within the hollow-stem augers. A typical as-built diagram that illustrates the monitoring wells installed at Buckley ANGB during the RI Part 2 is shown in Figure 2-1. Monitoring well completion forms and logs are presented in Appendix C.

Procedures for monitoring well installation (RI Part 2) are described as follows:

- Once the borehole was drilled to completion depth, an appropriate length (10 or 15 ft) of 4-inch diameter (I.D.) Schedule 40, 0.040-inch slot well screen and appropriate length of riser were installed. All screen and riser were threaded flush joint. The well screen and casing were steam cleaned prior to installation in the borehole. The screened interval extended approximately 2 to 5 feet above the water table to allow for annual fluctuation in the groundwater table. The top of the PVC casing was completed two feet above ground.
- The augers were raised in 2-foot increments, and Colorado silica sand (8 - 12) pack was added. The incremental lifting of the augers and emplacement of sand pack continued until the sand pack extended at least 2 feet above the top of the screen. Periodic sounding during this process ensured a continuous sand pack.
- After the sand pack was in place and measurements were taken to ensure its proper location, at least 2 feet of Volclay bentonite pellets (1/4 inch diameter) were placed on top of the sand pack.

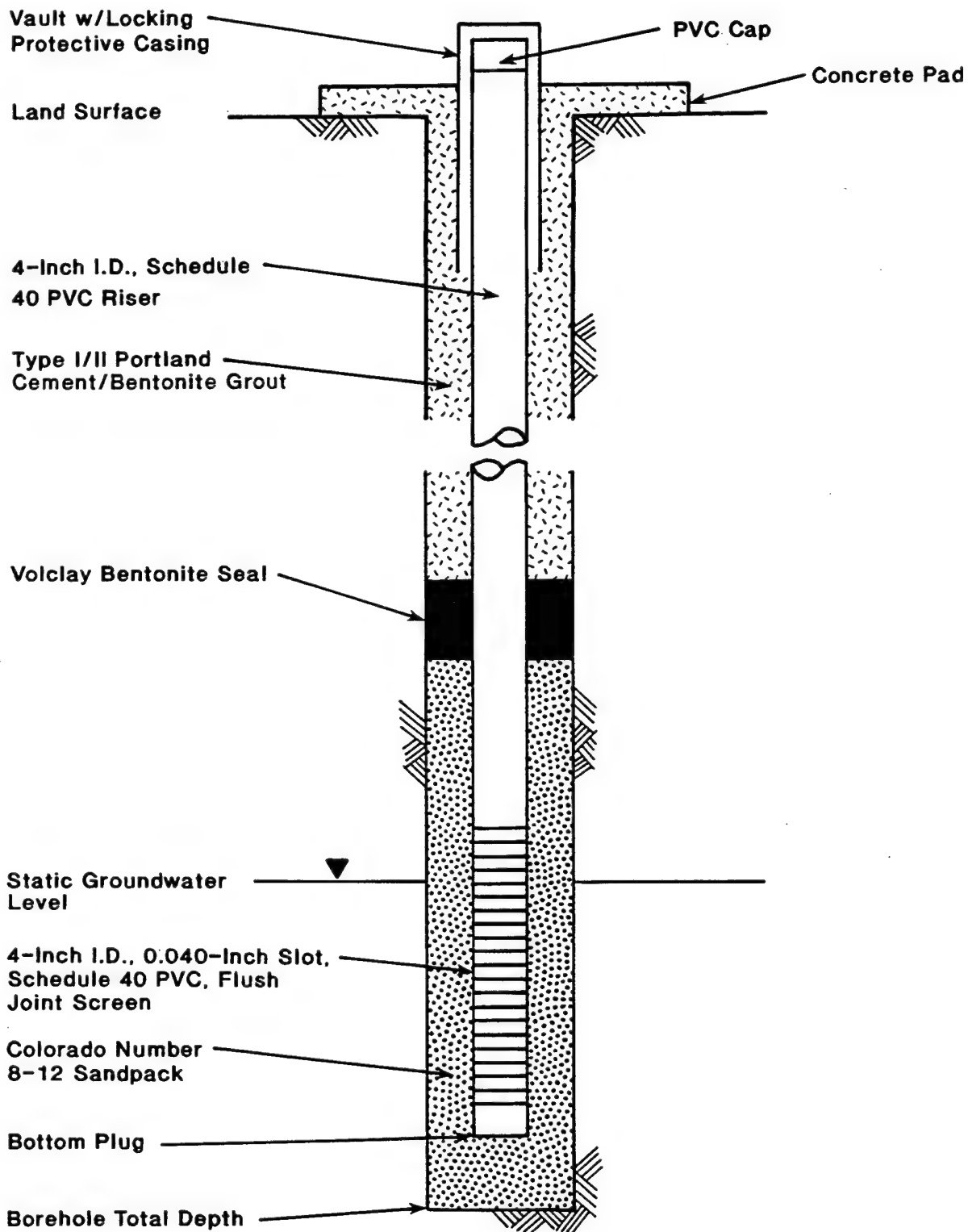


Figure 2-1. Above Ground Monitoring Well Completion, Buckley ANGB, Co.



- After the bentonite seal was in place and allowed to hydrate, measurements were taken to ensure its proper location. The PVC casing annulus was then grouted up to the ground surface with a bentonite/cement slurry. The bentonite/cement mixture consisted of potable water, bentonite, and Type I/II Portland cement with 94 pounds of cement and 3 to 5 pounds of bentonite per 6.5 gallons of water.
- Each well was completed with a locking, steel well cover and concrete pad. All wells were fitted with locks having identical keys.
- Each well was developed by surging and bailing until the well water was acceptable to the SAIC Supervisory Geologist (i.e., when clarity and specific conductivity stabilized and showed no further improvement or reduction with continued development). The total volume of removed water was estimated and recorded.
- After the wells were completed at each site, they were surveyed by Alpha and Omega Consultants of Aurora, Colorado for horizontal and vertical locations to define the groundwater flow direction. The surveys were completed to a vertical accuracy of 0.01 feet and a horizontal accuracy of 1.0 foot. All surveys were referenced to the U.S. Geodetic Survey elevation datum and the Colorado State System for horizontal location. Appendix C-1 presents the horizontal coordinates and elevation data of the monitoring wells installed during the RI Part 2 at Buckley ANGB.

Analytical methods, sample preservation guidelines and other pertinent chemical laboratory information for the groundwater sampling performed during the RI Part 2 are shown in Tables 2-1b and 2-2b, respectively. Results for all RI Part 2 chemical analyses are also presented in Appendix G, Laboratory Analytical Data.

2.1.4 Soil Boring Drilling, Sampling, and Abandonment

Soil borings were drilled at four sites during the RI Part 1 at Buckley ANGB. Two soil borings were drilled to a depth of 15 ft at Site 1 (Former Base Landfill) to detect any soil contamination emanating from the former oil pit area. One soil boring was drilled to a depth of 15 ft in depth at Site 3 (Former Fire Training Area No. 2) to determine the vertical extent of any contamination in the burn pit area. Two soil borings were completed to a depth of 15 ft at Site 4 (Fire Training Area No. 3) to determine the vertical extent of any contamination in the burn pit as well as adjacent to the fire training fuel storage area. Four soil borings were completed to a depth of 10 ft at Site 6 (Former Sewage Treatment Plant) to determine the vertical extent of contamination within the abandoned sludge drying beds and around the abandoned digester.

Soil borings were drilled at two sites (Sites 3 and 4) during the RI Part 2 at Buckley ANGB. These additional soil borings were needed to fill in data gaps from the RI Part 1. Four soil borings were drilled to a depth of 20 ft. in the burn pit area at Site 3 to determine the vertical contaminant extent for possible future excavation. Five soil borings were completed to a depth of 40 ft. at Site 4 in the burn pit area to also determine the vertical contaminant extent for future excavation.

TABLE 2-1b. SUMMARY OF METHODS FOR ANALYSIS OF SOIL AND WATER SAMPLES,
COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 2

Parameter	SOIL SAMPLES			WATER SAMPLES		
	Analytical Method ^a	Detection Limit ^b	Reporting Units	Analytical Method ^a	Detection Limit ^b	Reporting Units
<u>Organics</u>						
VOCs	SOW 3/90	c	µg/kg	SOW 3/90	c	µg/L
SVOCs	SOW 3/90	d	µg/kg	SOW 3/90	d	µg/L
Organochlorine Pesticides/PCBs	--	--	--	SW3510/8080	e	µg/L
Chlorinated Herbicides	--	--	--	SW8150	f	µg/L
<u>Inorganics</u>						
Priority Pollutant Metals						
Antimony	--	--	--	SW3005/6010	g	µg/L
Arsenic	--	--	--	SW3005/7041	3.0	µg/L
Lead	--	--	--	SW7060	1.0	µg/L
Mercury	SW3050/7421	5.0	mg/kg	SW3020/7421	1.0	µg/L
Selenium	--	--	--	SW7470	0.2	µg/L
Thallium	--	--	--	SW7770	2.0	µg/L
	--	--	--	SW3020/7841	1.0	µg/L
<u>Miscellaneous Inorganics</u>						
Asbestos	--	--	--	TEM	0.688	MFL

^a The methods cited are from the following sources:

"SOW" Methods - Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, EPA Contract Laboratory Program, March 1990 (Version OLMO 1.0)

"SW" Methods - Test Manuals for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Third Edition, EPA 1986 with 1989 revisions

"TEM Method" - Transmission Electron Microscopy

^b The detection limits presented represent those established by the laboratory for the analytical method indicated.

^c VOCs in water and soil/sediment samples and field QC blanks using the 3/90 SOW protocol for VOC analysis. Sample CRDLs are highly matrix-dependent. The CRDLs are provided for guidance and may not always be achievable. CRDLs are established for a wet-weight basis. Detection will usually be at or below the values specified. Medium soil/sediment CRDLs are 120 times the individual low soil/sediment CRDL.

^d Medium soil/sediment CRDLs for 3/90 CLP semivolatile target compounds are 30 times the individual low soil/sediment CRDL. Specific CRDLs are highly matrix-dependent. The CRDLs listed herein are provided for guidance and may not always be achievable. CRDLs listed for soil/sediment are based on wet-weight. Limits calculated on a dry-weight basis will be higher.

^e Organochlorine pesticides and PCBs in water samples and field QC blanks using EPA Method 8080 are listed in SOW 3/90. Sample PQLs are highly matrix-dependent. Factors for determining PQLs listed in the method are provided for guidance and may not always be achievable.

^f Chlorinated herbicides in groundwater and field QC blanks using SW8150 are listed in SW-846. Sample PQLs are highly matrix-dependent. Factors for determining PQLs listed in the method are provided for guidance and may not always be achievable.

^g Contract required detection limits (CRDLs) are the instrument detection limits obtained in laboratory-grade water that must be met when using the procedures described in Exhibit E of the CLP inorganics SOW. The detection limits for samples may be considerably higher depending on the sample matrix. If the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not be equal to the CRDL.

TABLE 2-2b. SUMMARY OF SAMPLE CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES OF WATER AND SOIL SAMPLES ACCORDING TO MEASUREMENT, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 2

MEDIA MEASUREMENT	CONTAINER TYPE	PRESERVATIVE	HOLDING TIME
AQUEOUS SAMPLES			
<u>Organics</u>			
VOCs	Three 40-ml glass vials*	HCl to pH < 2, 4°C	14 days
SVOCs	Two 1-l glass bottles**	4°C	7 days-extraction, 40 days-analysis
Organochlorine Pesticides/PCBs	Two 1-l glass bottles**	4°C	7 days-extraction, 40 days-analysis
Chlorinated Herbicides	Two 1-l glass bottles**	4°C	7 days-extraction, 40 days-analysis
<u>Inorganics</u>			
Priority Pollutant Metals,			
Arsenic	One 1.0-l polyethylene bottle	HNO ₃ to pH < 2, 4°C	6 months
Antimony	One 1.0-l polyethylene bottle	HNO ₃ to pH < 2, 4°C	6 months
Lead	One 1.0-l polyethylene bottle	HNO ₃ to pH < 2, 4°C	6 months
Mercury	One 1.0-l polyethylene bottle	HNO ₃ to pH < 2, 4°C	28 days
Selenium	One 1.0-l polyethylene bottle	HNO ₃ to pH < 2, 4°C	6 months
Thallium	One 1.0-l polyethylene bottle	HNO ₃ to pH < 2, 4°C	6 months
<u>Miscellaneous Inorganics</u>			
Asbestos	One 1.0-l glass bottle**	4°C	48 hours
SOIL AND SEDIMENT SAMPLES			
<u>Organics</u>			
VOCs	One 6 x 2.5 inch SS*** insert	4°C	14 days
SVOCs	One 6 x 2.5 inch SS*** insert	4°C	14 days-extraction, 40 days-analysis
<u>Inorganics</u>			
Lead	One 6.0 x 2.5 inch SS*** insert	4°C	6 months

* = Teflon lined septum cap
 ** = Narrow-mouth amber glass, Teflon-lined cap
 SS*** = Stainless Steel

Soil borings were drilled to obtain soil samples for in-depth laboratory analysis. Soil borings also had soil samples collected at 5-foot intervals utilizing split-spoons with 6-inch stainless-steel inserts. Each soil sample was screened on-site by ECS using the GC. In addition, each borehole had two samples sent to NET Pacific for in-depth analysis. The analytical methods, sample preservation guidelines and other pertinent chemical laboratory information for the RI Part 2 is presented in Table 2-1b and 2-2b. Results of all chemical analyses are presented in Appendix G. New borehole lithologic logs are included in Appendix C.

2.1.5 Sediment Sampling

Sediment samples were collected at three sites during the RI Part 1 at Buckley ANGB. Two sediment samples were collected from the Tollgate Creek bed from Site 1 (Former Base Landfill) and were used to assess the impact surface water runoff and groundwater discharge emanating from the site has on the creek and to determine the potential of off-site transport. Six sediment samples were collected from the perimeter of the aircraft parking apron at Site 5 (Storm Drainage System) to assess the impact of aircraft washing operations on storm water runoff and contaminant transport. Three composite sediment samples were collected from the abandoned sludge drying beds at Site 6 (Former Base Sewage Treatment Plant) to determine if the sludge is contaminated.

2.1.6 Hydrologic Data Collection

Two types of hydrologic data were collected at Buckley ANGB sites. Static groundwater level measurements were taken from all monitoring wells. These levels were used to determine depth to the water table which, once mapped, provided information on groundwater flow direction and hydraulic gradients. Coupling levels with well logs also aid in the determination of the aquifer type (confined vs. unconfined) screened by the well. Results of the aquifer "slug" tests were used to determine the hydraulic conductivity of the screened portion of the aquifer and yielded information about the storage coefficient of the aquifer. Collectively, the hydrologic data was used to determine the orientation of wells to each site with respect to groundwater flow direction and estimates of groundwater flow rates.

The first round of groundwater-level measurements was taken from within all monitoring wells installed at Buckley ANGB on January 20, 1989, one and one half months after the completion of RI Part 1 field work. This later measurement was necessary after previous water levels taken during October and November well drilling, installation, and sampling varied by as much as a foot. The low permeability of the soils, in which the groundwater monitoring wells were screened, and complex hydrogeology led to very slow water-level recovery that prolonged the effect of November and December well drilling, development, purging, sampling, and aquifer testing on the water levels within each well. A second round of groundwater-level measurements were taken from within all monitoring wells at Sites 1 and 4 on August 15-16, 1991, during the RI Part 2.

Aquifer (slug) testing was performed after the completion of groundwater sampling (RI Part 1). Slug tests are short-duration, single-well tests conducted by "instantaneously" adding or removing a slug of known volume into or from the well. The rate at which the water level (potentiometric head) recovers to static water level is a function of the hydraulic conductivity of an aquifer. Aquifer slug tests were taken from all 4-in monitoring wells. Because of the small size and generally poor condition of the 2-in monitoring wells installed during a previous study, slug

testing of these wells was impossible.

After the completion of the field program (RI Parts 1 and 2), all wells, borings, and soil-gas and geophysical survey grid corner points were surveyed for position. Positioning surveys were necessary in order to relate various geologic and hydrologic data between soil borings and monitoring wells and to quantify the locations of anomalies detected during the soil-gas and geophysical surveys.

2.1.7 Equipment Decontamination

Decontamination was performed in order to minimize the chance of cross-contamination between sampling points or as a result outside contamination of sampling tools. Two levels of equipment decontamination were performed at Buckley ANGB during both field investigations (RI Parts 1 and 2).

Sampling devices (i.e., splitspoons, bailers, trowels) were subjected to an extensive decontamination process prior to, between, and following sampling activities. The process consisted of: 1) scrubbing with a laboratory grade detergent (Alconox) and potable water solution, 2) a potable water rinse, 3) a purified water rinse, 4) a pesticide grade methanol rinse, and 5) a pesticide grade hexane rinse and air drying.

The second level, nonsampling equipment decontamination, was performed on all equipment which did not come into intimate contact with environmental samples (i.e., drilling rods, tools, etc.), and was a less rigorous decontamination process. This process consisted of high-pressure steam cleaning and laboratory-grade detergent (Alconox, Liqui-Nox) washing followed by potable water rinsing. All pieces of equipment were then covered with polyethylene plastic during storage and transport. Also, all non-sampling, down-well equipment (i.e., development pumps, water level sounders) were decontaminated by scrubbing with a laboratory-grade detergent, followed by potable water rinse.

2.2 DATA ANALYSIS PROCEDURES AND INFORMATION (RI Part 1)

Data collected during the RI Part 1 field program and subsequent chemical analysis were further processed and analyzed in order to provide results and conclusions regarding each site. Various data were processed in the following ways:

- Aquifer (slug) Testing Analysis - located in Appendix D. Provides aquifer parameters which are used to estimate the rate of transport in the groundwater at sites where monitoring wells were installed.
- Geophysical Survey Analysis - located in Appendix E and summarized in the Site 1 - Former Base Landfill discussion. Results are used to help locate areas of disposal and the size of any contaminant plume at the Base Landfill.
- Laboratory Chemical Analysis Data Reduction and Evaluation - tables located in Appendix G were condensed from approximately a 1200 page laboratory report. These tables were further summarized (for volume consideration) to achieve the format presented in this volume. A brief discussion of the chemical analysis data evaluation appears in Section 2.2.2.

- Laboratory Chemical Analysis QA/QC Program Evaluation - summarized in Section 2.2.1 and presented in Appendix H. Results are used to determine the validity, precision, and accuracy of the chemical analysis data.
- Public Health Risk Assessment - located in Appendix B and summarized in Section 2.2.3. Results appear in each site discussion (Sections 4 through 9). Results are used to determine the risk associated with any contamination found at the sites and compare this risk to background risks at Buckley ANGB.

2.2.1 Chemical Analysis QA/QC Assessment Summary (RI Part 1)

A number of QA/QC procedures were instituted throughout the field program and sample analysis at Buckley ANGB. The intent of these procedures is to ensure that collected samples are representative of the sites, and that analytical data accurately describe the characteristics and concentrations of compounds within the samples. The following is a summary of the assessment which is located in Appendix H.

Sample data quality is assessed through three basic types of QA/QC data, 1) field QA/QC samples, 2) laboratory QA/QC samples, and 3) adherence to sampling and analyses method procedures and guidelines.

2.2.1.1 Field QA/QC Samples (RI Part 1)

Trip blanks - were prepared by the laboratory supplying bottles prior to the beginning of the sampling trip by pouring organic-free water into sample bottles preserved with hydrochloric acid. Sample containers were filled and preserved to yield a representative blank for each type of VOC analysis, resulting in a complete trip blank for the sampling event. The analysis results of trip blanks were used to assess contamination of sample containers during transport to and storage at the site and contamination of samples during transport back to the laboratory. One trip blank was included in each shipping container containing samples for VOC analysis.

Field blanks (ambient conditions blanks) - were prepared at the beginning of each sampling event, at each discrete sampling site, by pouring reagent-grade water into prepared sample bottles. The field blanks were handled and analyzed in the same manner as the environmental samples particular to that site or zone. Because field blanks and environmental samples are collected under the same conditions, the results of the field blank analyses were used to indicate the presence of external contaminants (drill rig or aircraft exhaust, dust particles) that may have been introduced into samples during collection. Field blanks contaminated during transport were assessed by the simultaneous evaluation of trip blanks results.

Equipment blanks - were prepared for manual and small automated sampling equipment used to collect environmental samples. Equipment blanks were collected during the sampling day by pouring

reagent-grade water into/through/over a clean piece of sampling equipment, such as bailers, shovels, and trowels, and then dispensing it into prepared sample bottles. The results of the analyses of equipment were used to assess the efficiency of equipment decontamination procedures in preventing cross- contamination between samples.

Field replicates - were collected in quantities equal to 10% of the total number of environmental samples. These samples were collected at the same time and using the same techniques as the planned environmental samples. Replicate water samples were collected with a Teflon bailer while replicate soil samples were collected with a 2-in diameter split-spoon sampler at the same time as environmental sample collection. The results of the field replicate analyses were used to assess the precision of the field sampling methods.

2.2.1.2 Laboratory QA/QC Samples (RI Part 1)

Matrix Spike/Matrix Spike Duplicates - were prepared by adding a known amount of one or more compounds in an environmental sample then analyzing for those compounds. The duplicate allows the determination of the reproducibility of the result. The results were used to assess the analysis precision and recovery achieved from the matrix.

Method Blanks - were prepared prior to sample preparation within the lab by pouring reagent-grade into prepared sample bottles. The analysis of these blanks were used to assess outside contamination of the sample which may occur during sample preparation and analysis.

Spike blanks - were prepared by adding a known amount of one or more compounds into reagent-grade water. The analysis were used to assess analysis precision and recovery achieved from a clean matrix.

Surrogate spikes - were prepared by adding a known amount of one or more compounds into every environmental sample. The compounds used are not expected to be present in any of the environmental samples. Analysis results were used to determine matrix interferences on analysis results.

Holding blanks - were prepared by storing a sample of reagent-grade water with the environmental samples. Results were used to assess the outside contamination of environmental sample which can occur during sample storage within the laboratory.

2.2.1.3 Adherence to Sampling and Analysis Protocols and Procedures (RI Part 1)

There are set guidelines and methods for the sampling and analysis of environmental samples. Specifically, there are minimum numbers of field and laboratory QC samples which must be collected and holding times (time between sampling and extraction or analysis) which must be met. Insufficient QC sample collection can cause data deficiencies which will make data validation questionable or impossible. Failure to meet holding time requirements can result in lowered or elevated contaminants concentrations or no detection of compounds that are actually existing at the sampling site.

2.2.1.4 Summary of QA/QC Assessment Results (RI Part 1)

The assessment of the QA/QC data for Buckley ANGB indicates that the analysis results for environmental samples are valid. Sampling guidelines and QC requirements were met. QC samples showed acceptable replication and that decontamination procedures were acceptable. Laboratory analysis methods and QC requirements were followed and showed adequate accuracy, precision, and reproducibility.

There were several compounds which were found in the various field and laboratory blanks which affect the results of the environmental samples. Table 2-3 indicates these compounds, their suspected source, and how their presence effects the environmental sampling results.

2.2.2 Chemical Analyses Data Evaluation Methods (RI Part 1)

The first part of the chemical analyses data evaluation (RI Part 1) was performed to condense the data into summary tables which include only the contaminants found at a particular site in each specific media. It should be remembered that these tables do not provide a complete listing of the compounds analyzed. A complete listing of the results for each sample appear in Appendix G.

Contaminants listed in the summary tables were then compared to the results of the laboratory QA/QC evaluation (Section 2.2.1 and Appendix H) and to background sampling results (Section 3.2). This allowed the identification of compounds which were not attributable to site activities but were the result of contamination during sampling or analysis, and/or the result of background conditions.

Any organic compounds which were detected in the sample and not eliminated during the QA/QC evaluation or background sampling were considered site-related contamination.

For inorganic compounds the 95% confidence interval, approximately the mean concentration of the background sampling results, was calculated and compared to the environmental sample concentrations. Any inorganic concentration which exceeded the 95% confidence interval was considered a site-related contaminant. Furthermore, information from Dragun (1988) on worldwide natural concentrations of inorganic compounds was used to determine if metals concentrations were of a plausible natural origin.

2.2.3 Data Quality Assessment (RI Part 2)

A standardized quality assurance/quality control (QA/QC) program was followed during the Remedial Investigation (RI) conducted for the Colorado Air National Guard at Buckley ANGB, Aurora, Colorado to ensure that analytical results and the decisions based on these results were representative of the environmental condition at the sites. The objective of the RI Part 2 was to confirm the presence of contamination, collect and analyze sufficient numbers of samples to determine the lateral and vertical extent of contamination detected during the original field effort (RI Part 1), and conclude RI activities at six sites. The RI Part 2 was conducted using the Hazardous Waste Remedial Actions Program (HAZWAP) Level C (i.e., U.S. Environmental Protection Agency [EPA] Level III) QC requirements described in *Requirements For Quality Control Of Analytical Data* (DOE/HWP-65/R1, July 1990). A comprehensive QA assessment is presented in Appendix H of this report. The QC checks and results, applicable to the 1991 field effort, are summarized below.

Table 2-3. Summarization of Compounds Found in Field and Laboratory Blanks at Colorado Air National Guard,
Buckley Field, Aurora, Colorado

Analyses/Compound	Suspected Source	Effect on Environmental Sample Analysis Result
PURGEABLE ORGANICS (EPA Method SW-8240)		
Acetone	Ambient conditions during sampling or decontamination remnant	Acetone found in borings at Site 1 - Former base landfill is not considered environmental contaminants.
2-butanone	Decontamination remnant	None
Carbon disulfide	Decontamination remnant	None
Chloroform	Laboratory contamination, probably during storage	Chloroform found in environmental samples is not considered environmental contamination.
Methylene chloride	Laboratory contamination during sample preparation	Methylene chloride found in environmental samples is not considered environmental contamination.
Tetrachloroethene	Decontamination remnant	None
Trichlorethane	Decontamination remnant	None
EXTRACTABLE ORGANICS (EPA Methods SW-3550 (soil) or SW-3510 (water) and SW-8270) Bis(2-ethylhexyl) phthalate		
	Laboratory contamination, probably during sample preparation	Bis (2-ethylhexyl) phthalate found in environmental samples is not considered environmental contamination.
ORGANOCHLORINE PESTICIDES (EPA Methods SW-3550 (soil) or 3510 (water) and SW-8080)		
	No compounds found in blanks	None

Table 2-3 (Continued)

Analyses/Compound	Suspected Source	Effect on Environmental Sample Analysis Result
CHLORINATED HERBICIDES (EPA Methods SW-8150)	No compounds found in blanks	None
INORGANICS (Various methods)		
Calcium	Present in reagent-grade water	None
Mercury	Decontamination remnant	None
Nitrate	Present in ambient sampling conditions	Discount validity of nitrate present in associated groundwater samples.
Phosphorus	Present in reagent-grade water	None
Potassium	Present in reagent-grade water	None
Thallium	Present in reagent-grade water	None
Zinc	Present in reagent-grade water	None

2.2.3.1 Data Quality Objectives

The following sections summarize the data quality objectives (DQOs) for precision, accuracy, representativeness, comparability, and completeness (PARCC) obtained during the RI Part 2 at Buckley ANGB.

2.2.3.1.1 Precision

Precision was determined using matrix spike/matrix spike duplicate (MS/MSD) and duplicate sample analyses conducted on samples collected for volatile organic compound (VOC), semivolatile organic compound (SVOC), pesticide/polychlorinated biphenyl (PCB), and chlorinated herbicide analyses and priority pollutant metals (including total lead only) analyses, respectively, during the RI Part 2. Two RPD values calculated from the VOC analyses were outside the EPA Contract Laboratory Program (CLP) advisory control limits for analytical precision. Since each analysis was evaluated according to the required QC criteria described in Appendix H (Section H.3) and all of these criteria were met for the environmental samples analyzed, these RPD values are considered to be a more representative reflection of the variability characteristic of the environmental condition at Buckley ANGB, and as a result, the analytical DQO for VOC and SVOC precision is considered to have been met. Ten SVOC RPD values calculated from the SVOC analyses were outside the EPA CLP advisory control limits, including eight values calculated from F3B-12(21.5-22). These results were rejected due to poor system performance compound recoveries. Since the analytical MS/MSD frequency requirement had previously been met and all other RPD values were within the control limits, the analytical DQO for SVOC precision is considered to have been met. All priority pollutant metals RPD values (of the 27 values calculated) were within the control limits, except chromium, copper, and zinc. Therefore, the analytical precision DQO for these metals analyses is considered to have been met.

Sample collection reproducibility and media variability were measured in the laboratory by the analysis of field replicates. Field RPD values were calculated only for compounds and elements detected above the contract required detection limits (CRDLs) in both replicate pair samples and only for those compounds and elements not considered to be common laboratory contaminants (e.g., methylene chloride). As a result, no pesticide/PCB or chlorinated herbicide RPD values could be calculated. All VOC and SVOC RPD values were less than the applicable control limit, except the SVOC 2-methylphenol (97 percent). This value is attributed to matrix variability and the uneven distribution of contaminants within the soil column, and as such, is not considered to have an adverse impact on the associated environmental data quality. All priority pollutant metals RPD values were less than the applicable control limit, except for one lead value (i.e., 114 percent) in F3B-11(1.5-2.0). This value is considered to be the result of natural matrix variability that could not be overcome by the sample mixing conducted before the sample portion collected for priority pollutant metals analyses was containerized.

2.2.3.1.2 Accuracy

Sampling accuracy was maximized by adherence to the strict QA program presented in DOE/HWP-65/R1. All procedures (i.e., soil boring and monitoring well installation, soil and groundwater sample collection procedures, equipment decontamination, and health monitoring equipment calibration and operation) used during the RI Part 2 were documented as standard operating procedures (SOPs). Field QC blanks (i.e., trip blanks, field blanks, and equipment blanks) were prepared to ensure that all samples represent the particular site from which they were collected, assess any cross-contamination that may have occurred, and qualify the associated analytical data accordingly.

Accuracy was determined using MS/MSD and matrix spike analyses conducted for VOC, SVOC, pesticide/PCB, and chlorinated herbicide, and priority pollutant metals (including total lead only) analyses, respectively, during the RI Part 2. Laboratory accuracy was qualitatively assessed by evaluating the following laboratory QC information: sample holding times, method blank, tuning and mass calibration (gas chromatography/mass spectrometry [GC/MS] only), system performance compound and surrogate recovery (GC/MS and GC, respectively, only), internal standard (GC/MS only), Laboratory Control Sample (LCS) and method blank spike recovery, and initial and continuing calibration results calculated from all analyses conducted on environmental samples.

All percent recoveries were within the control limits for MS/MSD analyses conducted on the samples collected and analyzed for VOCs, except for the trichloroethene recoveries in one spiked sample. All percent recoveries were within the control limits for the MS/MSD analyses conducted on the samples collected and analyzed for SVOCs, except six compounds. These results were rejected due to poor system performance compound recoveries. Since all other RPD values were within the control limits, the analytical DQO for SVOC precision is considered to have been met. All supporting VOC and SVOC QC information cited above also was qualitatively evaluated with respect to the analytical accuracy DQO. Methylene chloride was detected in nearly all laboratory method blanks, in addition to several field QC blanks associated with the environmental samples collected during the RI Part 2. As a result, all methylene chloride concentrations detected in the environmental samples were excluded from use in the RI Part 2 decision making process, since the concentrations detected did not exceed five times that detected in any QC blank. The analytical data collected from one SVOC analysis (i.e., F3W-01-10W) was rejected due to system performance compound recovery results, and as a result, will not be used in the RI Part 2 decisionmaking process. The analytical data collected from one VOC reanalysis (i.e., F3B-12 (1.5-2.0)R) were qualified due to system performance compound recovery results. One environmental sample collected for SVOC analysis was re-extracted beyond the applicable holding time and the results were qualified accordingly. The analytical data collected from one SVOC reanalysis (i.e., F2B-7(1.5-2.0)R) were qualified due to internal standard results. These results are not considered to have any adverse impact on the environmental data quality, except where noted.

Twenty-seven priority pollutant metals percent recovery values were calculated from the matrix spike analyses conducted on the soil and groundwater samples collected at Buckley ANGB. All recoveries were within the applicable control limits, except selenium in one matrix spike sample, and as a result, all associated environmental sample results were qualified accordingly. Despite these values, no systematic laboratory error was detected, since all LCS criteria for soil samples were met. As a result, all associated soil data were qualified for data validation purposes, as required by EPA validation guidelines; however, the results are considered to have little impact on the overall

environmental data quality. All percent recovery values calculated from the matrix spike analyses conducted on the water samples collected during the RI Part 2 were within the applicable control limit. All supporting priority pollutant metals QC information cited above also was qualitatively evaluated with respect to the analytical accuracy DQO. Zinc and lead were detected in the laboratory method blanks at concentrations less than the CRDL, but greater than the Instrument Detection Limit (IDL). As a result, the concentrations of these elements detected in five groundwater samples were qualified as estimated (i.e., "J[MB]") due to laboratory method blank interference, since these concentrations did not exceed five times that detected in the associated blank.

Based on the evaluation of the MS/MSD results and the associated laboratory QC results, the overall laboratory accuracy is acceptable, and as such, the analytical DQO for accuracy was met, except where noted.

Methylene chloride was detected at concentrations greater than the contract required quantitation limit (CRQL) in three equipment blanks. This compound could not be attributed to the laboratory environment, and as a result, all concentrations of methylene chloride detected in the associated soil samples were considered estimated and qualified accordingly (i.e., "J[EB]").

Lead was detected in one field blank and zinc was detected in one equipment blank. No data validation qualifiers were applied to the lead and zinc concentrations detected in the associated environmental samples, since these elements were detected at concentrations less than five times that detected in the associated laboratory method blanks.

Based on an evaluation of the compounds and elements detected in the field QC blanks, the overall field accuracy is acceptable, except where noted. As a result, the field DQO for accuracy is considered to have been met.

2.2.3.1.3 Representativeness

Representativeness was defined as the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling location, a process condition, or an environmental condition. Sample representativeness was ensured during the RI by collecting sufficient samples of a population medium, properly distributed with respect to location and time. Representativeness was assessed by reviewing the drilling techniques and equipment; well installation procedures and materials; and sample collection methods, equipment, and sample containers used during the RI Part 2, in addition to the onsite GC analysis results and evaluating the RPD values calculated from the duplicate samples and the concentrations of interferences detected in the field and laboratory QC blanks. The reproducibility of a representative set of samples reflects the degree of heterogeneity of the sampled medium, as well as the effectiveness of the sample collection techniques.

All monitoring wells were installed using hollow stem auger drilling techniques. This method is commonly used to install monitoring wells to depths less than 100 feet. All samples were collected using the split-spoon driven in front of the auger. As specified in the Addendum to the Remedial Investigation/Feasibility Study (RI/FS) Work Plan, submitted in May 1991, California ring samplers (i.e., stainless steel liners inserted into a split-spoon sampler) were to be used to collect all soil samples.

Based on the evaluation of the field methods described above, the field and laboratory QC blank results, the samples collected during the RI Part 2 are considered to be representative of the environmental condition at Buckley ANGB, Colorado.

2.2.3.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another and is limited to the other PARCC parameters, because only when precision and accuracy are known can one data set be compared to another. To optimize comparability, only the specific methods and protocols that were required by DOE/HWP-65/R1 were used to collect and analyze samples during the RI Part 2. By using consistent sampling and analysis procedures, all data sets were comparable within the sites at Buckley ANGB, between sites at the installation, or among ANG facilities nationwide, to ensure that remedial action decisions and priorities were based on a consistent data base. Comparability also was ensured by the analysis of EPA reference materials, establishing that the analytical procedures used were generating valid data.

All samples collected for VOC and SVOC analysis were analyzed using the March 1990 EPA CLP Statement of Work (SOW). Samples collected for pesticides/PCBs, chlorinated herbicides, and priority pollutant metals analyses were analyzed using EPA solid waste methods.

Based on the precision and accuracy assessment presented above, the data collected during the RI Part 2 are considered to be comparable with the data collected during the previous investigation.

2.2.3.1.5 Completeness

Completeness was defined as the percentage of valid data obtained from a measurement system. For data to be considered valid, they must have met all acceptance criteria, including accuracy and precision, as well as any other criteria specified by the analytical methods used. Based on the evaluation of the field and laboratory QC results presented in Appendix H (Sections H.2 and H.3), 98.1 percent of the environmental sample data collected during the RI Part 2 were used as the basis for recommendations presented in this report.

Project completeness was defined as the percentage of data used in the RI Part 2 decision-making process. For analytical data to be considered usable for this purpose, they must be satisfactorily validated. Rejected (i.e., due to blank interference or surrogate and internal standard recoveries) values and concentrations reported for all analyses were not used in the risk estimates or for remediation recommendations due to the increased potential of using the concentrations of false positive compounds and elements or omitting compounds or elements (i.e., false negatives) that may have an adverse impact on human health. As a result, 36 VOC and 63 SVOC points were rejected, and as a result, were not included in the RI Part 2 decisionmaking process.

2.2.4 Public Health Risk Assessment Summary

The evaluation of the risk associated with any contamination is necessary in order to determine the impact of any site contamination on human health and the environment. The following is a summary of the methods and procedures which were followed in order to perform a baseline public health risk assessment. A full discussion is presented in Appendix B and the results of the assessment are presented in the individual site by site discussions.

Following EPA guidelines (USEPA 1986 a,b,c, 1988), the public health risk assessment can be divided into four fundamental component analyses: 1) hazard identification; 2) exposure assessment; 3) toxicity or hazard assessment; and 4) risk characterization. Hazard identification is the selection of "highest risk" compounds based upon the quantity, mobility, persistence, and toxicity of the compounds found at the site. Exposure assessment is the determination of exposure pathways (i.e., drinking of groundwater), populations exposed (i.e., Base personnel), and extent of exposure (intensity, duration, frequency). The toxicity or hazard assessment is the evaluation of the inherent toxicity of the compounds identified during hazard identification. These toxicities are found in literature resultant through compound dose/subject response studies on human and non-human receptors and include carcinogenic and noncarcinogenic effects. The risk characterization is the final step in the public health risk assessment and consists of combining all of the above information and through a series of calculations, and determining if a risk is associated with any contamination found at a site.

In addition to the calculation of risk, any contamination found at the sites are compared to Applicable or Relevant and Appropriate Requirements (ARARs). ARARs, in this case, are regulations promulgated by various local to national agencies for the protection of human health or the environment which define maximum tolerable concentrations of contaminant compounds allowed in drinking and/or surface water supplies.

3.0 REGIONAL ENVIRONMENTAL SETTING

This section presents the background environmental setting which is necessary for assessing any site impacts upon human health or the environment and for determining the significance of the environmental data collected. A thorough knowledge of the hydrogeology is necessary because it is the soil and groundwater at the sites which are most likely affected by any contamination and govern the fate and transport of contamination. The background environmental chemistry of soils and groundwater were determined in order to evaluate, which contaminants are of site origin and which are naturally occurring or a result of contamination from other off-base sources.

3.1 HYDROGEOLOGY

3.1.1 Regional Hydrogeologic System

The U.S. Geological Survey recently completed an extensive series of studies of the hydrogeologic system along the Front Range of Colorado. The study included investigations of geologic structure, hydraulic characteristics, and water quality of the principal groundwater aquifers (Robson and Romero 1981a; Robson and Romero 1981b; Robson et al. 1981a; Robson et al. 1981b; Robson 1983; and Hillier et al. 1983). The following discussion is based upon salient aspects of that study, results of the present investigation, and other references as cited.

3.1.1.1 Regional Geologic Framework

Buckley ANGB is positioned within the Denver Basin of Colorado. This basin covers an area of approximately 6700 square miles (mi^2) and is analogous in shape to a shallow (relative to its width) bowl shaped depression which has been filled in with over 3500 ft of sedimentary rocks generally from erosional processes within the mountains to the west (Figure 3-1). The sedimentary rocks which have filled the basin are comprised of six geologic formations, in descending order within the basin: the Castle Rock Conglomerate; Dawson Arkose; the Denver, Arapahoe, and Laramie Formations; and the Fox Hills Sandstone. The Pierre Shale, an 8000-ft thick formation consisting primarily of relatively impermeable shale, forms the bottom of the Denver Basin.

The Castle Rock Conglomerate and Dawson Arkose occur only within the central portion of the Denver Basin which are removed from Buckley ANGB, and are therefore not considered further herein. The Denver Formation (and associated aquifer) and eolian surficial deposits which outcrop within the Base area, would be the most likely formation to be affected by hazardous waste handling, storage, and disposal activities at the Base and is therefore the focus of this study. The underlying Arapahoe and Laramie Formations, and the Fox Hills Sandstone are not likely to be affected by Base activities because of the great thickness of and hydrogeological conditions within the Denver Formation and the relatively low volumes of hazardous waste handled, stored, or disposed of on the Base. Therefore, they will only be briefly discussed.

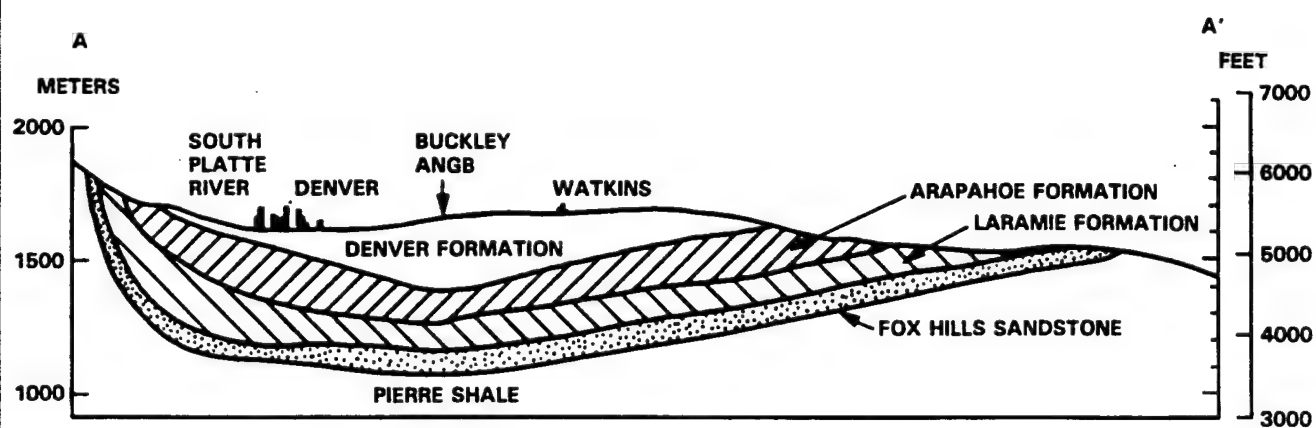
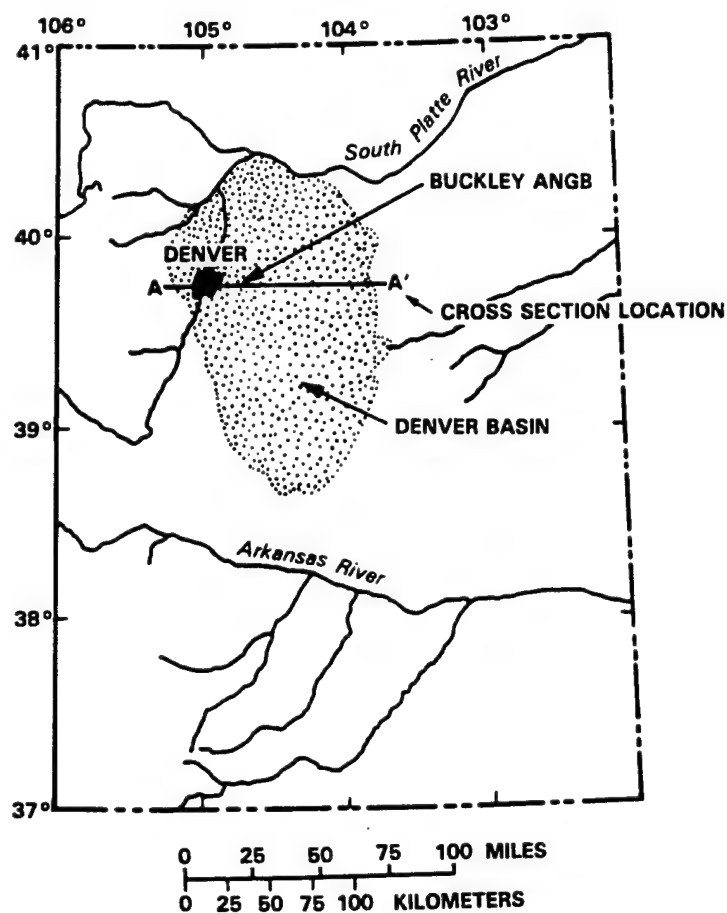


Figure 3-1. Index Map of the Denver Basin and Generalized Geologic Section.
(Modified from Robson and Romero, 1981 b)

The Denver Formation is a 600- to 1000-ft thick (approximately 850 ft in the Base area) sequence of variably consolidated, interbedded shale, claystone, siltstone, and sandstone which occurs in poorly defined lenticular beds. The formation is primarily (70%) composed of thick sequences of shale and claystone with the other 30% composed of coarser grained sediments irregularly dispersed in beds ranging in thickness from a few inches to as much as 50 ft. The Denver Formation is characterized by its olive, green-grey, brown, and tan color derived from the erosional source in the mountains of like-colored basaltic and andesitic lava flows. Other characteristics are the presence of thin coal beds, and the high percentage of shales and mudstones.

Within the outcrop area of the Denver Formation, as at Buckley ANGB, this formation is covered with a thin mantle (generally less than 10 ft) of windblown deposits of loess and fine sand. Additionally, in ancient and present stream and river valleys, there are alluvial deposits which were derived from the relatively recent erosion of the Denver Formation. In the Base area, these alluvial deposits exist along Tollgate and Coal Creeks and their tributaries. These alluvial deposits tend to be coarser grained than their erosional source beds.

Underlying the Denver Formation are: 1) the 400- to 700-ft thick Arapahoe Formation of interbedded conglomerate, sandstone, siltstone, and shale; 2) the Laramie Formation with 400 to 500 ft of shale, coal and minor siltstone and sandstone beds; 3) the 200- to 300-ft thick Fox Hills Sandstone of primarily sandstone with minor thickness of shale, and; 4) the 5,000- to 8,000-ft thick Pierre Shale of predominantly shale with very minor beds of siltstone and sandstone.

3.1.1.2 Regional Hydrogeology

Four aquifers are located within the sandstone, conglomerate, and siltstone beds of the Denver Basin. The claystones and shales form relatively impermeable confining layers which impede vertical, and because of the general lenticular structure of the sedimentary beds, horizontal groundwater flow. In descending order within the basin, these aquifers are the Dawson, Denver, Arapahoe, and Laramie-Fox Hills Aquifers. The latter is a combination of the coarser grained beds from both the Laramie Formation and Fox Hills Sandstone. For reasons cited above, the Denver and associated surficial aquifers will be the focus of this study. Figure 3-2 depicts the conceptual regional hydrogeologic system in the Denver area, defined as the Nonglaciaded Central groundwater region (Heath 1984).

The Denver Aquifer consists of the variably consolidated sandstone, conglomerate, and siltstone deposits of the Denver Formation. Only an estimated 30% of the deposits within the Denver Formation fit this description. Both water table and confined conditions occur within the Denver Aquifer. Generally, water table conditions exist where the Denver Formation outcrops, or is overlain by alluvial deposits or eolian deposits as in the vicinity of Buckley ABGB. In the central portion of the Denver Basin, where the Denver Formation is overlain by the Dawson Arkose, confined conditions generally are present. Recharge to the Denver Aquifer in outcrop areas occurs by direct infiltration of precipitation and irrigation water in highland areas and by downward leakage in the

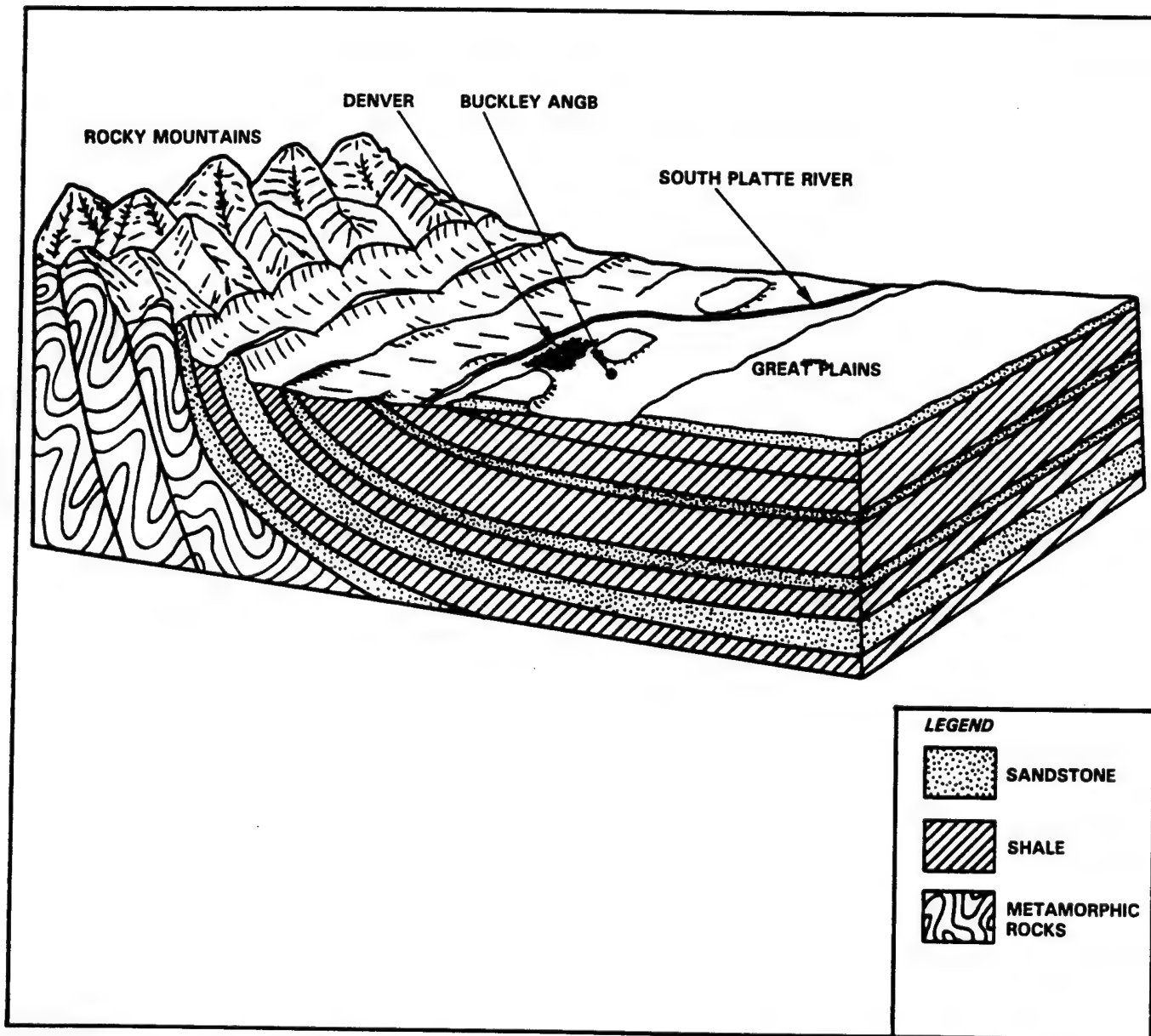


Figure 3-2. Conceptual Model of the Regional Hydrogeologic System at Buckley ANGB, Aurora, Colorado. (Modified from Heath, 1984)

upland reaches of stream and river valleys by alluvial aquifers. Recharge in the central portion of the Basin principally occurs from downward leakage of groundwater from overlying formations. Groundwater discharge is primarily in the form of seepage and evapotranspiration into valleys where the aquifer outcrops providing baseflow to local streams and rivers and is also responsible for the concentration of vegetation in the stream valleys. Additionally, minor but significant amounts of groundwater are discharged from the aquifer by downward seepage into the underlying Arapahoe Aquifer and to pumping wells. Groundwater flow within the Denver Aquifer is generally radially outward from the center of the basin. In the Buckley ANGB area, where the aquifer outcrops, flow on the regional basis is toward the northwest toward the South Platte River which serves as groundwater divide within the aquifer and is a major discharge area for the aquifer. Hydraulic conductivity has been found to be as high as 3×10^{-4} ft/sec for long screened sections of the aquifer but values on the order

of 2×10^{-5} ft/sec are documented in the general vicinity of Buckley ANGB. Storativity values where unconfined conditions exist within the Denver Formation range from 0.09 to 0.33 and range from 2×10^{-4} to 6×10^{-4} in confined portions of the aquifer. Maximum transmissivity values for the Denver Aquifer are 3000 gpd/ft, but values reported within the Base vicinity are in the 375 gpd/ft range. These values for the aquifer parameters of the Denver indicate that the aquifer is a relatively poor producer of groundwater and relatively large thickness of the aquifer must be screened in order to produce significant quantities of groundwater. This is directly related to the large percentage of relatively impermeable fine grained sediments, and the limited areal extent and lenticular structure of the water producing sandstone, conglomerate, and siltstone beds within the Denver Formation.

Other important aquifers in the Denver Basin, especially in the Buckley ANGB area, are located within the present and ancestral surficial stream and river valleys. These 20- to 100-ft thick deposits form the alluvial aquifer system in the area and are the result of erosion of upland bedrock areas. Unconfined conditions exist in this aquifer because of its surficial setting and relatively coarse grained nature. Groundwater recharge to this aquifer is a result of a direct infiltration of precipitation and irrigation water and by lateral and upward seepage of groundwater in the downstream reaches of the valleys. Groundwater discharge from the alluvial aquifers is through seepage to streams, evapotranspiration, downward seepage into underlying bedrock aquifers and by extraction via pumping wells. (It is important to note that these recharge/discharge relationships are dynamic and are primarily dependent upon seasonal and yearly variations in precipitation and irrigation.)

Groundwater flow is generally downstream and toward the stream channel. In the Base area, this flow is thought to be toward the northwest following the trend of the stream valleys. Aquifer parameter information is limited, however, because of the coarse-grained nature of the alluvial aquifers. The hydraulic conductivity and storage values are probably higher than the underlying bedrock aquifers. Transmissivity values vary greatly from very small values in the upstream reaches where the alluvium is thin and finer grained to relatively high along the South Platte River where alluvium thicknesses are relatively great and the grain size coarser. Because of this variation, well yields within this aquifer range from below 100 gpm in the upper reaches of the stream valleys to over 1600 gpm in wells in the South Platte River Valley.

The aquifers underlying the Denver Formation, the Arapahoe and Laramie-Fox Hills Aquifers, share similar hydrogeologic characteristics with the Denver Aquifer. These underlying aquifers differ primarily in the greater percentage of area where confined conditions exist and in the larger percentages of water bearing strata within the host formations which lead to a greater capacity to transmit groundwater. The Pierre Shale which underlies the Basin forms a relatively impermeable base to the Denver Basin aquifer system.

3.1.1.3 Groundwater Use and Development

The Denver Basin aquifer system is a secondary source of drinking water for suburban Denver and surrounding rural communities. Wells have tapped the water producing capabilities of all aquifers in the Denver area. Generally, for cost reasons, shallow wells are drilled into the outcropping formation at the drilling site or in nearby alluvial valleys.

Within a 2-mi radius downgradient of Buckley ANGB area the Colorado Division of Water Resources has registered over 170 wells (Dames & Moore 1987). The majority of these wells are screened within the shallow alluvial aquifers which exist in Sand Creek and its tributary valleys, although some wells are screened through large thicknesses of outcropping Denver Formation.

Groundwater use has resulted in water level drawdowns in excess of 200 ft in some areas. The city of Aurora, which supplies drinking water for the environs of Buckley, draws 90% of its water from surface sources. Within the Buckley ANGB area, water levels have risen as much as 50 ft from levels noted 20 to 40 years ago. This rise has been attributed to the recharge effect of the Cherry Creek Reservoir located approximately 4 mi from the Base.

3.1.1.4 Water Quality of the Denver Aquifer

Water in the Denver Aquifer is generally of good chemical quality, meeting drinking water standards (Colorado Department of Health 1976, 1977) for public supplies in all areas except the extreme northern part of the aquifer where the water contains high concentrations of dissolved-solids and especially dissolved sulfates. The water in the central portion is classified as a calcium bicarbonate type and changes to a sodium bicarbonate or sodium sulfate type near the margins. The calcium bicarbonate type is a result of calcium bicarbonate water of the overlying Dawson Aquifer moving down into the Denver Aquifer. As the water moves laterally through the Denver Aquifer, it is naturally softened by ion-exchange (calcium ions for sodium ions) on the surface of clay minerals within the Denver Formation. In the areas of outcrop of the Denver Aquifer, as in the Base Area, the availability of oxygen in the surficial soils and bedrock leads to the formation of soluble minerals in the sediments, coal, and organic material which are common in the formation. Downward percolation of precipitation then carries the soluble minerals into the groundwater. This process along with ion-exchange lead to the sodium bicarbonate or sodium sulfate type waters found in the outcrop areas of the Denver Aquifer.

The concentrations of dissolved solids in the groundwater is a measure of the mineral content of the water. Concentrations of dissolved solids in the Denver Aquifer are generally less than 300 mg/l in the central part of the aquifer (and the Denver, Aurora area) but increase to over 1000 mg/l along the marginal outcrop area. This trend in rising dissolved solids is, again, attributable to the differences in recharge sources discussed above. Additionally, the increased mineral concentration is further enhanced around the margins by lateral thinning of the aquifer concentrating the dissolved minerals in a smaller volume of water.

Inorganic materials present in the Denver Formation alters the chemistry of the water by decreasing the oxygen content which leads to the dissolution and transportation of iron, which is normally insoluble. Upon extraction and subsequent exposure to oxygen the iron precipitation may occur. Iron content of water in the Denver Aquifer varies, but generally dissolved iron concentrations range from 10-150 mg/l which is below the limit of 300 mg/l recommended by the U.S. Environmental Protection Agency (1977).

Generally, groundwater in the Base area represents some of the better quality water of the Denver Aquifer. It is soft water with low concentrations of dissolved-solids, dissolved-sulfate, and dissolved-iron, making it good quality water for public use. The Base is located within the outcrop area of the Denver Formation and is susceptible to the formation of soluble minerals and metals in the vadose zone which can be transported into the groundwater by infiltration.

3.1.2 Base-wide Hydrogeology

This section summarizes the base-wide characteristics of the hydrogeology at Buckley ANGB. Site specific hydrogeologic results appear in each site by site discussion in Sections 4.0 through 9.0. These characteristics were determined through geologic and hydrogeologic data collected during the SAIC field program as described in Section 2.0. Data collected during previous studies (Dames & Moore 1986; Dames & Moore 1987) was also incorporated into this summary. Note that the focus of this investigation was the surficial aquifers at the Base, namely the alluvial and Denver Aquifers. Because the structure, the preponderance of fine-grained rocks within the Denver Formation, and the relatively small quantities of hazardous substances handled, stored, or disposed of, contamination below the Denver Aquifer is extremely unlikely at Buckley ANGB even though a downward hydraulic gradient probably exists. The following specific data included in this report which were used to create this summary:

- Soil Boring and Monitoring Well Logs and Completion Forms found in Appendix C
- Static water level elevations (RI Parts 1 and 2) presented in Table 3-1
- Potentiometric surface maps developed for the respective sites
- Aquifer Test Data, presented in Appendix D and summarized in Table 3-2.

TABLE 3-1. STATIC GROUNDWATER ELEVATIONS FOR COLORADO AIR NATIONAL GUARD,
BUCKLEY FIELD, AURORA, COLORADO

SITE/WELL NUMBER	STATIC WATER LEVEL			
	01/20/89		08/15&16/91	
	DEPTH (FT BLS)	ELEVATION (FT ABOVE MSL)	DEPTH (FT BLS)	ELEVATION (FT ABOVE MSL)
Site 1: Former Base Landfill				
LFW-5	11.6	5514.22	13.90	5511.94
LFW-6	32.7	5508.53	35.25	5505.94
LFW-7	16.8	5504.24	22.60	5498.44
LFW-8	12.9	5492.09	12.83	5492.17
MW-1 *	25.5	5526.00	23.54	5526.26
MW-2 *	16.9	5541.27	40.55	5520.02
MW-3 *	16.9	5501.06	Dry	Dry
MW-4 *	14.8	5500.51	Dry	Dry
LFW-13	--	--	14.30	5502.36
LFW-14	--	--	16.17	5506.96
LFW-15	--	--	10.63	5512.33
LFW-16	--	--	22.80	5524.82
LFW-17	--	--	17.67	5531.82
Site 2: Former Fire Training Area No. 1				
F1W-3	9.1	5556.28	--	--
Site 3: Former Fire Training Area No. 2				
F2W-3A (shallow)	25.7	5575.25	--	--
F2W-3B (deep)	28.2	5572.79	--	--
F2W-4	24.8	5571.13	--	--
F2W-5	25.1	5572.16	--	--
Site 4: Fire Training Area No. 3				
F3W-3	39.2	5499.08	40.70	5497.60
F3W-4	39.0	5497.72	40.12	5496.28
F3W-5	38.4	5497.96	39.90	5496.50
F3W-8	--	--	40.18	5495.75
F3W-10	--	--	39.93	5496.41
F3W-13	--	--	40.46	5495.94
Site 6: Former Sewage Treatment Plant				
MW-1 *	48.6	5433.41	--	--
MW-2 *	48.6	5432.73	--	--
MW-3 *	Dry	Dry	--	--
Background Well				
BGW-2	14.0	5595.38	--	--

BLS - Below Land Surface.

MSL - Mean Sea Level Datum.

* - Denotes monitoring wells which were installed during a previous study.

-- - Static water levels not taken.

TABLE 3-2. AQUIFER TEST RESULTS, COLORADO AIR NATIONAL GUARD,
BUCKLEY FIELD, AURORA, COLORADO

SITE/WELL NUMBER	HYDRAULIC CONDUCTIVITY (ft/min)	STORATIVITY	ANALYSIS METHOD/COMMENTS
SITE 1 - FORMER BASE LANDFILL			
LFW-5	2.2 E-02	*	Hvorslev method, unconfined aquifer, sandpack drainage influence suspected
LFW-6	5.9 E-05 - 1.2 E-04	0.01	Cooper method, confined aquifer
LFW-7	2.1 E-01	*	Hvorslev method, unconfined aquifer, sandpack drainage influence suspected
LFW-8	1.1 E-02	*	Hvorslev method, unconfined aquifer
SITE 2 - FORMER FIRE TRAINING AREA NO. 1			
F1W-3	2.0 E-02	*	Hvorslev method, unconfined aquifer
SITE 3 - FORMER FIRE TRAINING AREA NO. 2			
F2W-3A	--	--	Uninterpretable results
F2W-4	4.6 E-04	0.001	Cooper method, confined aquifer
F2W-5	6.2 E-05	0.01	Cooper method, confined aquifer
SITE 4 - FIRE TRAINING AREA NO. 3			
F3W-3	4.5 E-02	*	Hvorslev method, unconfined aquifer
F3W-4	2.4 E-01	*	Hvorslev method, unconfined aquifer
F3W-5	5.1 E-02	*	Hvorslev method, unconfined aquifer
BACKGROUND WELL			
BGW-2	2.8 E-04	0.01	Cooper method, confined aquifer

* - Storativity cannot be calculated from the Hvorslev method of analysis.

The subsections which follow present detailed descriptions of hydrogeologic conditions at each specific site. There are, however, a number of hydrogeologic characteristics which are consistent across the Buckley ANGB area and can be addressed in a single discussion which applies to and sets a framework for all of the individual sites.

The general geologic setting of Buckley ANGB is depicted in Figures 3-3 and 3-4. Only one formation, the Denver Formation, was encountered during the drilling program at the base. Associated alluvial deposits and surficial eolian deposits were also encountered.

The alluvial deposits encountered were confined to stream valleys, which run through Site 1-Former Base Landfill, Site 2-Former Fire Training Area No. 1, and in the BGW-2 background well location. Discerning the alluvial deposits from the Denver Formation is difficult because the alluvium is derived from the Denver Formation. Nonetheless, the alluvial deposits appear to be a maximum 10- to 15-ft thick in the central portions of the valley, gradually decreasing in thickness along the valley flanks. The sediments in these deposits share the same general characteristics of the source rock (the Denver Formation) except that they tend to be coarser grained and more homogeneous.

A surficial layer of eolian deposits was also encountered. These consisted of fine sand and loess deposits. The loess was exposed at the land surface throughout the base and generally tended to be less than 5 ft in thickness and consisted primarily of a brown silt with traces of very fine sand and clay. An underlying windblown brown fine sand deposit was difficult to differentiate from the underlying Denver Formation because of the similarity between the two but appears to be 5 to 20 ft in thickness. The fine sand eolian deposits were principally found in the central portion of the Base as shown in Figure 3-3.

The majority of drilling activities were performed within the Denver Formation. This unit which exhibited the regional characteristics that were noted previously including the large percentage of fine grained materials, the olive, green-grey, and brown color, the presence of coal seams, and the variation in degree of consolidation. Shale, coal, clay, silt, mudstones, and sandstone units were all encountered during drilling. These rock types vary greatly in thicknesses, degree of consolidation, and in areal extent, reflecting the lenticular structure of the beds. This variation is so great and irregular that beds from wells as close as 100 ft cannot be correlated with any degree of confidence; therefore, geologic cross-sections are not included in this report.

The water-bearing strata encountered at the Base are primarily limited to the Denver Formation because of the relative thinness of the eolian and alluvial deposits and depth of the water table (Figure 3-4). The variation in thickness and areal extent of individual beds of varying hydrologic properties (highly permeable sands vs. low permeability clays and shales) lead to an extremely complex hydrogeologic system at Buckley ANGB. On a regional scale, the Denver Aquifer is under water table conditions; however, on a local scale, both confined and semiconfined conditions occur because of the variation in rock types and thickness. Perched water table conditions undoubtedly also exist during parts of the year. Also, it is likely that these conditions change as seasonal fluctuations in the water table occur, possibly creating perched water tables and water table conditions as water levels fall and locally confined conditions as water levels rise.

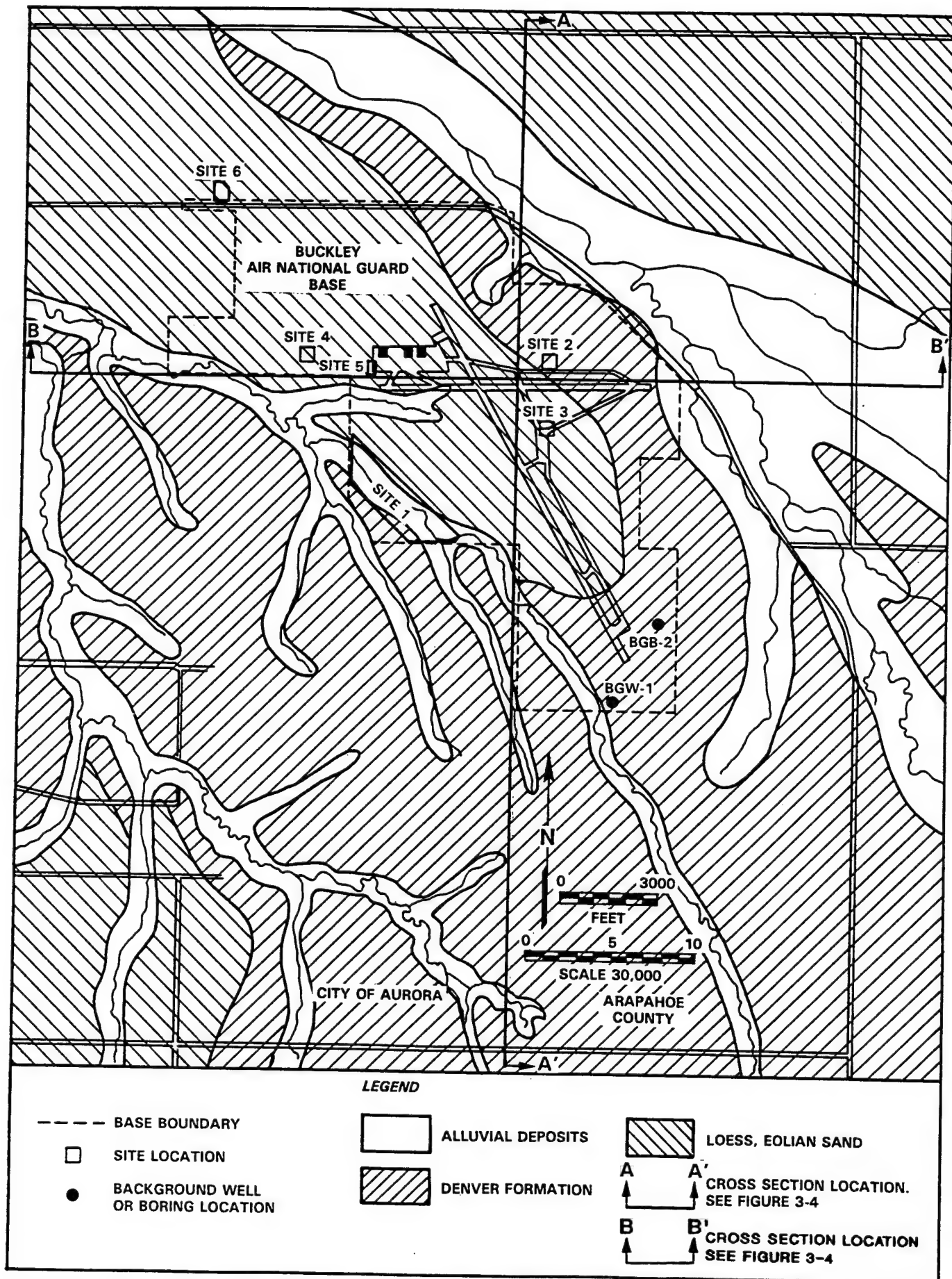
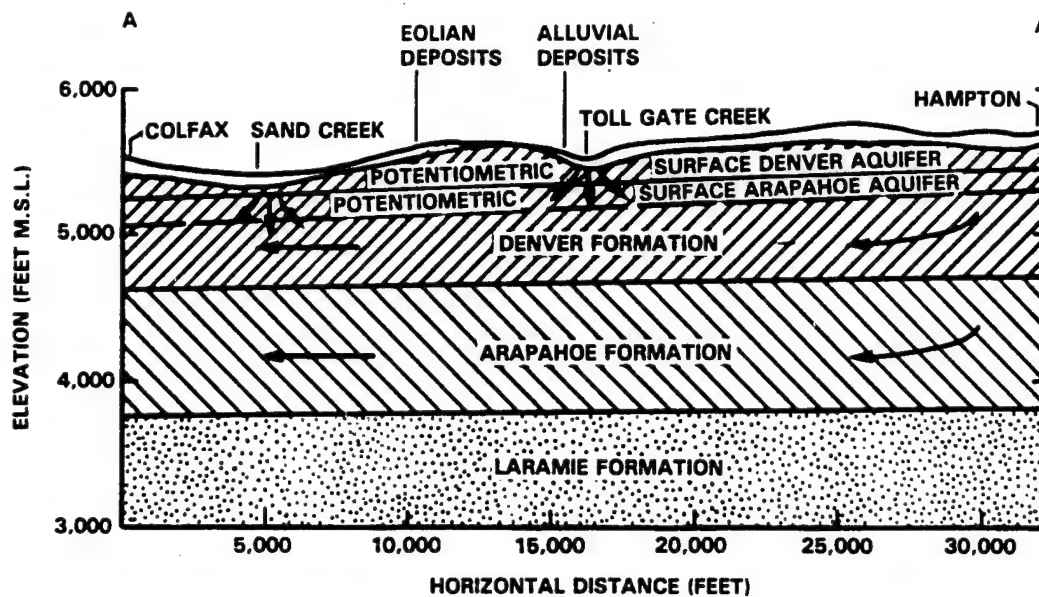


Figure 3-3. Surfacial Geology at Buckley ANGB (Simons, Li & Assoc., 1982).



LEGEND

← DIRECTION OF GROUNDWATER FLOW

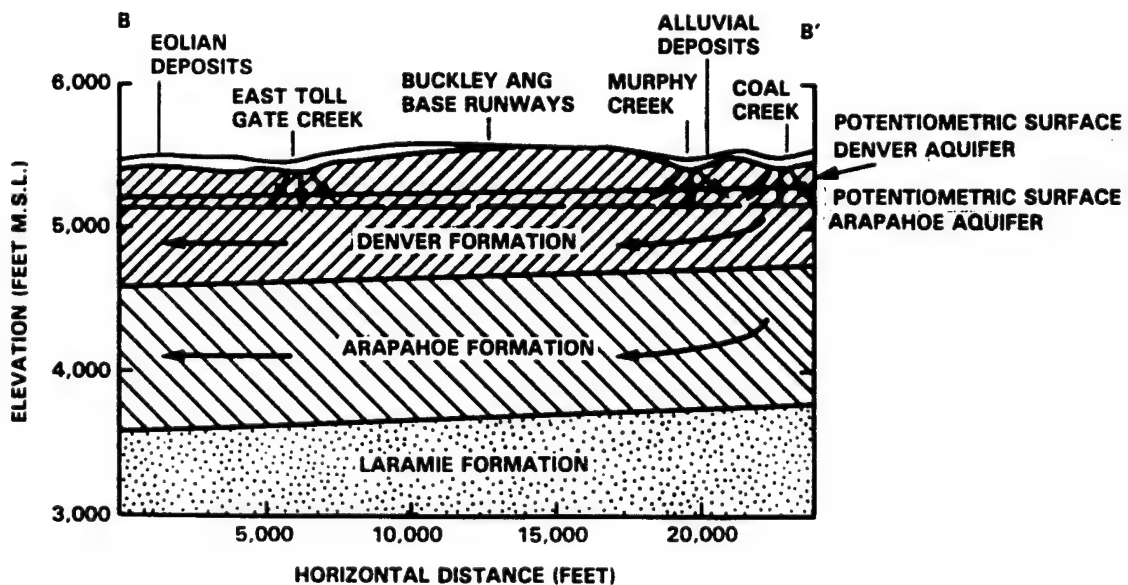


Figure 3-4. Generalized Geologic Cross Section at Buckley ANGB. See Figure 3-3 for Cross Section Location (Dames and Moore, 1987; Modified from Robson and Romero, 1981 b).

Static groundwater measurements (Table 3-1) taken during the RI Part 1 range from 9.1 ft below land surface (BLS) at Well F1W-3 at Site 2-Former Fire Training Area No. 1 to 48.6 ft BLS at MW-1 and MW-2 at Site 6-Former Sewage Treatment Plant. The potentiometric surface ranges in elevation from 5432.73 ft above Mean Sea Level (MSL) at Site 6-Former Sewage Treatment Plant to 5595.38 ft above MSL at background well BGW-2 located in the far southeastern portion of the Base. These levels compare, within 2 ft, with levels taken in October 1986 in the previously installed wells at the Base. These levels show that groundwater flow is toward the northwest in agreement with the previously noted regional flow that is dominated by the aquifer discharge area along the South Platte River. Close inspection of water levels show that the potentiometric surface generally mimics topography which, coincidentally, also generally slopes to the northwest. This reflects the recharge effects of precipitation infiltration in the upland areas at the Base and the discharging of groundwater to Tollgate Creek and Sand Creek Valleys. Three facts which should be kept in mind while assessing the potentiometric surface at the base are: 1) significant seasonal water-level changes throughout the year which, when coupled with the complex hydrologic properties of the Denver Aquifer, may cause flow direction changes; 2) because of the various aquifer types (confined vs. water table), care should be taken in comparing static water levels; and 3) because downward gradients exist at the base, water levels within wells represent an equilibrium state that is dependent on the total depth of the well and the lithology encountered within each well. Apparent hydraulic gradients (RI Part 1) range from 0.02 at Site 1-Former Base Landfill to .0015 at Site 3-Former Fire Training Area No. 2. Comparing these values to topography at the respective sites shows this is a result of the potentiometric surface reflecting surface topography.

One nested well pair (F2W-3A and B) was installed at Buckley ANGB. Static water levels within these wells show that there is a sizeable (0.15 ft) downward hydraulic gradient between the upper and lower wells. Even though these are limited data, this downward gradient is in agreement with previous studies on the Denver Aquifer, and indicates that this downward gradient probably exists throughout most of the Base. However, because of the existence of a large percentage of low permeability shale, claystone, and mudstone beds, the great majority of groundwater flow is still within a horizontal plane. This is in agreement with regional properties of the aquifer, as discussed in previous sections.

Aquifer slug testing (Table 3-2) conducted during the RI Part 1 yielded values of hydraulic conductivity values ranging from 4×10^{-4} ft/sec (1.2×10^{-2} cm/sec) to 1×10^{-6} ft/sec (3.0×10^{-5} cm/sec) in the wells installed at the Base during this study. These tests are generally considered only to be +/- one order of magnitude in accuracy. However, these values agree well with literature on the Denver Aquifer, as discussed earlier in this section. These values are in agreement with values cited in literature for silt, silty sand, and fine-to-coarse sands, which are screened by the wells at the Base (Freeze and Cherry 1979). Hydraulic conductivity values showed no apparent trends across the Base. Storativity values, yielded from the testing of monitoring wells locally under confined conditions, ranged in the 10^{-2} to 10^{-3} range. Because of existing analysis methods, these values are generally considered to be only within +/- 2 to 3 orders of magnitude in accuracy and are therefore limited in value. Regional values of storativity, cited in literature previously discussed, are in the 10^{-6} range, lower than those derived from testing performed in this effort. This can be attributed either to

analysis inaccuracy but may reflect semi- or poorly-confined aquifer conditions in this area.

3.2 BACKGROUND SAMPLING RESULTS

Knowledge of background concentrations of contaminants are necessary in order to determine which, if any, contaminants are of site origin and which can be attributed to other causes. These sampling points consist of one soil boring (BGB-1) and one groundwater monitoring well (BGW-2). The locations of these points are shown in Figure 3-5. In order to determine background concentrations of contaminants, two background sampling points were established in relatively undeveloped, hydraulically upgradient locations at Buckley ANGB.

Background contaminants occur for several reasons. First, they can be of natural origin, soils and groundwater commonly contain natural concentrations of heavy metals and may contain organic contaminants in petroleum and coal rich areas. Secondly, widespread application of agricultural chemicals or airborne pollution "fallout" can effect background concentrations. Lastly, the presence of hydraulically upgradient waste disposal facilities can result in elevated background concentrations.

3.2.1 Monitoring Well Borehole Soil Sample Results

Two soil samples (from 8 to 10 ft and 19 to 21 ft) and a groundwater sample were collected from the background monitoring well boreholes during the RI Part 1, and sent to the contract laboratory for analysis. The analyses were identical to those performed on the monitoring station samples. Summaries of the compounds detected in the background soil samples are presented in Table 3-3. Table 3-4 presents the calculated average concentration, the standard deviation, reporting limit, the 95% confidence interval for each priority pollutant metal, and the expected background ranges for metals found at other sites throughout the world.

No volatile or semivolatile organic compounds and no chlorinated pesticides or herbicides were detected above reporting limits in the background soils. Nine priority pollutant metals (arsenic, beryllium, total chromium, copper, lead, mercury, nickel, selenium, and zinc) were detected in the background soils above laboratory reporting limits, although not above the average soil background range. Antimony, cadmium, silver, and thallium were not detected in the background soils at the laboratory reporting limits shown.

3.2.2 Groundwater Results

Table 3-5 summarizes the compounds detected in the background groundwater sample collected during the RI Part 1. Methylene chloride was the only volatile organic compound detected in the groundwater above the reporting limits, but is not considered an environmental contaminant at this

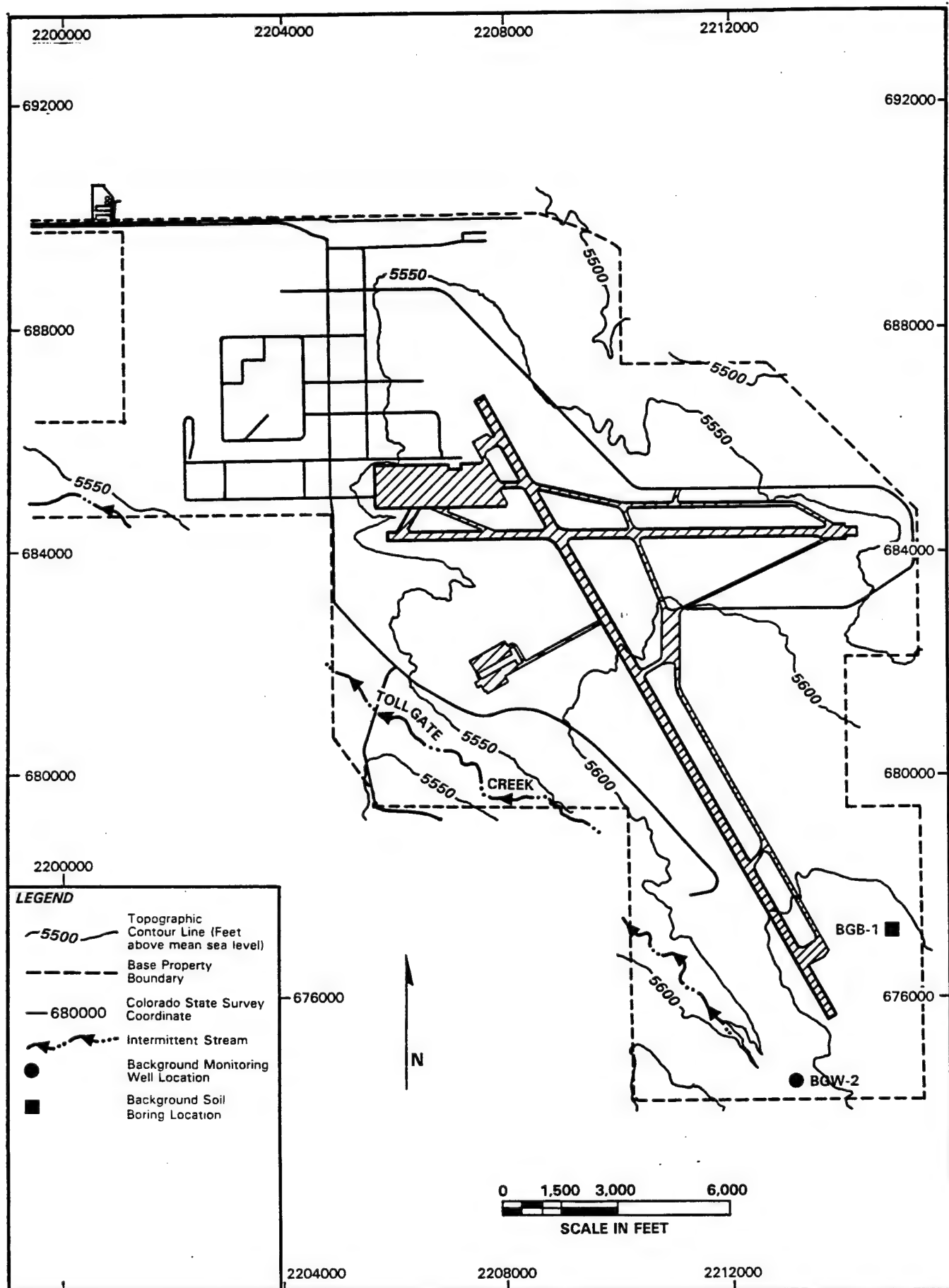


Figure 3-5 Location of Background Monitoring Wells, Colorado Air National Guard, Buckley Field, Aurora, Colorado

Table. 3-3 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN BACKGROUND SOIL SAMPLES, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE	UNITS	Sample #:BGW-2(8-10)Sample #:BGW-2(19-21)			
		Assoc. QA/QC	TB-12	FB-16	Assoc. QA/QC
		Result	Limit	Result	Limit
VOLATILE ORGANICS (Method 8240)					
		ND		ND	
SEMI-VOLATILE ORGANICS (Method 8270)					
		ND		ND	
CHLORINATED PESTICIDES					
		ND		ND	
CHLORINATED HERBICIDES					
		ND		ND	
INORGANICS					
% MOISTURE	wt %	6.9		5.6	
ARSENIC	mg/Kg	2	0.53	3.5	0.52
BERYLLIUM	mg/Kg	0.71	0.22	0.83	0.22
CADMIUM	mg/Kg	ND	2.5	ND	2.5
CHROMIUM, TOTAL	mg/Kg	12	4.5	11	4.5
COPPER	mg/Kg	20	3.4	31	3.4
LEAD	mg/Kg	9.3	0.53	9.4	0.52
MERCURY	mg/Kg	0.052	0.01	0.017	0.01
NICKEL	mg/Kg	9.7	5.6	8.1	5.6
SELENIUM	mg/Kg	0.7	0.53	ND	0.53
SILVER	mg/Kg	ND	4.5	ND	4.5
TIN	mg/Kg	ND	1	ND	1
THALLIUM	mg/Kg	ND	1.1	ND	1
ZINC	mg/Kg	59	1.1	87	1.1

LEGEND

ND- Not Detected

TABLE 3-4. COMPARISONS OF BACKGROUND SOIL SAMPLE RESULTS WITH
PUBLISHED BACKGROUND LEVELS OF SELECTED TRACE METALS
IN SOIL (PPM)

Analyte	BGW-2 (8-10)	BGW-2 (19-21)	Mean	Std Dev	Upper, 95% CI ^b	Background ^c Range
As	2	3.5	2.75	1.06	7.5	1-40
Be	0.71	0.83	0.77	0.085	1.1	0.1-40
Cd	nd	nd	2.5 ^a	2.5 ^a	14	0.01-7.0
Cr	12	11	11.5	0.71	15	5.0-3000
Cu	20	31	25.5	7.8	60	2.0-100
Pb	9.3	9.4	9.35	0.071	10	2.0-200
Hg	0.052	0.017	0.0345	0.025	0.15	0.01-0.08
Ni	9.7	8.1	8.9	1.13	14	5.0-1000
Se	0.7	nd	0.7 ^a	0.7 ^a	3.8	0.1-2
Ag	nd	nd	4.5 ^a	4.5 ^a	25	0.1-5
Sb	nd	nd	1.0 ^a	1.0 ^a	5.5	0.6-10
Tl	nd	nd	1.1 ^a	1.1 ^a	6	ng
Zn	59	87	73	19.8	160	10-300

^adetection limit

^bbased upon a single sided student's t at the 95% level with degree of freedom and N = 2. The 95% CI has been added to the mean or the detection limit to yield the upper 95% confidence interval.

^cfrom Dragun (1988)

nd = not detected, ng = not given

Table. 3-5 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN BACKGROUND GROUNDWATER
SAMPLES, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE		UNITS	ANALYSIS RESULT	REPORTING LIMIT
FIELD ANALYSIS				
pH		units	7.61	
Temperature		deg C	11.5	
Conductivity		umhos/cm	1020	
VOLATILE ORGANICS (Method 8240)				
Methylene Chloride		ug/L	8.9	5.00
SEMI-VOLATILE ORGANICS (Method 8270)			ND	
CHLORINATED PESTICIDES			ND	
CHLORINATED HERBICIDES			ND	
INORGANICS				
CALCIUM		ug/L	16000	50
CHLORIDE		mg/L	19.3/22.9	0.1
MAGNESIUM		ug/L	24000	200
NITRATE		ug/L	7.54	0.01
PHOSPHOROUS		mg/L	0.02	0.03
POTASSIUM		ug/L	3500	19
SELENIUM		ug/L	13	2
SODIUM		ug/L	100000	900
SULFATE		ug/L	327	0.2
ZINC		ug/L	22	10

LEGEND

ND- Not Detected

location because it is a common laboratory solvent (as discussed in Appendix H). No semivolatile organic compounds and no chlorinated pesticides or herbicides were detected in the groundwater.

Selenium and zinc were the only priority pollutant metals detected in the groundwater. Zinc was detected at 22 mg/l, which is two orders of magnitude (100 times) below the maximum contaminant levels (MCLs) established in the Safe Drinking Water Act. Selenium was detected at 13 mg/l, which is above the MCL, indicating that selenium may naturally occur at higher concentrations in this area. In addition, MCLs are determined for dissolved constituents, and the groundwater sample contained suspended solids which may have contributed to higher selenium concentrations.

Major cations (calcium, magnesium, potassium, and sodium) and anions (chloride, fluoride, phosphorous, nitrate, and sulfate) were detected in the groundwater at concentrations within ranges expected for alluvial aquifers in this area (Hillier et al. 1983). All detected concentrations of these parameters were also below recommended State of Colorado standards for public-water supplies (Colorado Department of Health 1971) except for sulfate. Sulfate concentrations above standards have been detected in other alluvial wells near the Base, indicating that the sulfate may occur naturally at higher concentrations. However, the standards were established for dissolved constituents, and suspended solids in the groundwater samples may have contributed to higher sulfate concentrations. Hardness of the water was calculated at 500 mg equivalent CaCO_3/l using the Method 314A (Standard Methods for the Examination of Water and Wastewater 1985), and it is within expected ranges (Hillier et al. 1983). In addition, asbestos was sampled for in the background monitoring well (BGW-2) during the RI Part 2. Asbestos was not detected in this groundwater sample.

3.2.3 Background Groundwater Contaminant Concentration Comparisons to ARARs

In order to examine the magnitude of these background levels of contamination, a summary table (Table 3-6) has been prepared showing mean and maximum levels of inorganic toxicants in background groundwater. Since no detectable quantities of organic substances were detected, there are no ARAR tables for that type of contaminant. For comparison, the applicable or relevant and appropriate requirements (ARARs; i.e., federal and state water-quality criteria and standards) are included. As specified in the Superfund Amendments and Reauthorization Act of 1986 (SARA), on-site remedial actions are required to attain ARARs unless such requirements are formally waived. A detailed explanation of ARARs and how they are to be used can be found in Appendix B.

Referring to Table 3-6, it is observed that reported levels of nitrate, sulfate, and zinc are significantly below all ARARs. Selenium is slightly higher than the MCL and the Colorado Drinking Water Standard. As discussed in Section 3.3.2, selenium occurs naturally at levels above the MCL in the Buckley ANGB area. There are no known ARARs or TBC guidelines for calcium, chloride, magnesium, phosphorous, potassium, and sodium. Since all detected quantities of organic and inorganic compounds are below ARAR levels or TBC guidelines or there is a reasonable explanation

TABLE 3-6. ARARs FOR INORGANIC CHEMICALS FOR BACKGROUND GROUNDWATER AT THE BUCKLEY ANGB

Inorganic Constituent	Mean Concentration (ug/L)	Maximum Concentration (ug/L)	Drinking Water		Adjusted for Drinking Water Only (ug/L)	Colorado Drinking Water Standards (ug/L)	Federal Water Health Advisories (g)		
			MCL (ug/L)	MCLG (ug/L)			One-Day 10 kg (ug/L)	Ten-Day 10 kg (ug/L)	Longer-Term 70 kg (ug/L)
Calcium	160,000	160,000							
Chloride	22,000	22,000							
Magnesium	24,000	24,000							
Nitrate	7.5	7.5	10,000	10,000	10,000 ^(d)	10,000	111,000	111,000	111,000
Phosphorous	20	20							
Potassium	3,500	3,500							
Selenium	13	13	10	45 ^(d)	10	10			
Sodium	100,000	100,000							
Sulfate	327	327	250,000 ^(e)						
Zinc	22	22	5,000 ^(e)		5,000 ^(f)	5,000			

(a) Maximum Contaminant Levels established under the Safe Drinking Water Act.

(b) Maximum Contaminant Level Goal established under the Safe Drinking Water Act.

(c) Ambient Water Quality Criteria established under the Clean Water Act, adjusted for drinking water.

(d) Proposed MCL or MCLG.

(e) Secondary Maximum Contaminant Level (SMCL) established under the Safe Drinking Water Act - not an ARAR.

(f) Criterion established based on taste and odor effects (organoleptic) not human health effects.

(g) Federal Drinking Water Health Advisories are not ARARs, but values to be considered (TBC) in evaluating the significance of observed levels of contamination in drinking water supplies.

(h) Drinking Water Health Advisory for a 10 kg child.

(i) Drinking Water Health Advisory for a 70 kg adult.

(j) Since one sample was taken from only one well the mean and the maximum were assumed to be the reported values from that well.

(not related to hazardous material disposal or handling practices) for the occurrence of elevated levels, a risk characterization was not conducted for the groundwater consumption pathway.

4.0 SITE 1 - FORMER BASE LANDFILL AND FORMER OIL PIT

This section provides information specifically pertaining to Site 1. This includes past investigation activities, remedial investigation (RI) objectives and activities performed, the results and significance of RI findings, risk assessment results, and conclusions and recommendations. Background information of past activities is provided in Sections 4.1 and 4.2. A complete description of activities and results of IRP Phase II, Stage 1, Part 1 activities are presented in "Installation Restoration Program, Phase II- Confirmation/Quantification Stage 1, Buckley Air National Guard Base" (Dames & Moore 1986).

4.1 SITE DESCRIPTION AND PREVIOUS WORK

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley ANGB and to assess potential for contaminant presence and migration. This phase consisted primarily of interviews and record review.

The Former Base Landfill received Buckley municipal refuse from 1942 to 1982 and refuse from Lowry AFB during the early 1960s. Trench-and-fill methods were used. Between 1947 and 1959 (during Navy occupation), and perhaps later, the landfill was burned periodically, probably using waste oil and other flammables to aid combustion. Materials disposed of in the Former Base Landfill included building materials, paint cans, solvent containers, pesticide containers, municipal refuse, fuel tank sludges, and construction rubble.

The Former Oil Pit was taken out of service and backfilled with gravel in 1987. The pit reportedly measured about 10 ft by 10 ft and was 15 ft deep, enclosed at the sides and bottom by continuously-poured concrete. Contents of the Former Oil Pit were burned occasionally during the 1950s. Specific information about other materials that may have been placed in the pit is unavailable; however, disposal of solvents may have occurred. The depth to groundwater at this location has been estimated as less than 20 ft below land surface.

IRP Phase II, Stage 1, Part 1, Confirmation/Quantification (Site Inspection)

Field investigations were conducted at Site 1. Activities included drilling, sampling, and logging of four monitoring wells. Water levels were measured for each new well, and chemical analyses of soil and water samples were performed.

Chemical analyses (see Table 4-1) indicated that soils contain up to 4100 mg/kg of total organic carbon (TOC), indicating possible contamination. Cadmium was detected in groundwater at concentrations up to twice the primary drinking water standards (up to 0.02 mg/l). TOC (6 to 39 mg/l) and total organic halogens (TOX; ~65 µg/l) were detected in wells hydraulically upgradient and downgradient of the landfill. Phenolics were detected up to 30 µg/l in Well MW-3 (near the Former Oil Pit).

TABLE 4-1. ANALYTICAL RESULTS FOR SITE 1 - FORMER BASE LANDFILL AND FORMER OIL PIT

Parameter (Sample Depth-Feet)	Method	Unit	Detection Limit	Groundwater Samples				Soil Samples							
				MW-1	MW-3	MW-4		MW-1	MW-2	MW-3	MW-3	MW-3	MW-4	MW-4	
								(20- 21.5)	(43- 43.5)	(0- 1.5)	(5- 6.5)	(15- 16.5)	(0- 1.5)	(5- 6.5)	
Cadmium	213.1 ^a	mg/l	0.01	0.02	0.02	0.01									
Nickel	249.1 ^a	mg/l	0.05	0.08	0.09	0.09									
Silver	272.1 ^a	mg/l	0.01	0.02	0.02	0.01									
Phenolics	420.2 ^a	ug/l	10	10	30	10		8	5	ND	3	ND	ND	ND	ND
Total Dissolved Solids	160.2 ^a	mg/l	1	3500	2300	2500									
Total Organic Carbon	415.1 ^a	mg/l	1	6.1	39	6.4		1200	870	3700	2400	2700	4100	1400	
Total Organic Halocarbons	9020 ^b	ug/l	10	64	65	63		ND	ND	ND	ND	ND	ND	ND	
Moisture Content	160.3 ^a	Percent	1					10	10	13	9	22	15	8	
pH	Field	Std	0.1	6.9	6.8	6.8									
Temperature Specific	Field	°C	0.1	13.8	13.0	12.0									
Conductance	Field	umhos/cm	1	4651	2852	2772									

^a Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.^b Test Methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, Modified for use on 0.1. Corp Model 610 TOX Analyzer.

ND - indicates value less than detection limits.

Source: Dames & Moore, 1986 and 1987. "Installation Restoration Program, Phase II - Confirmation/Quantification, Stage 1."

The Site Inspection did not adequately determined background contaminant concentrations, the extent of site contamination, nor the precise limits of the landfill boundary. At the time of planning the RI reported on herein, information identified to complete data gaps included soil lithology, spatial continuity of soil types, confirmation of surface water contamination, and hydrogeologic properties including local groundwater gradients.

Recommendations for further investigation included:

- Resample for cadmium presence and distribution
- Perform a geophysical electromagnetic conductivity survey
- Install four new wells at Site 1.

4.2 REMEDIAL INVESTIGATION ACTIVITIES

Remedial investigation activities were based upon findings of the Preliminary Assessment (Phase I Records Search) and two earlier investigations (Phase II Stage 1, parts 1 and 2-Confirmation/Quantification). Objectives of the RI were to:

- Determine if contamination of the various environmental media at Site 1 is present
- Identify the source(s) and nature of any contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risk any present contamination may pose to public health, thereby determining the need for remedial actions.

RI Part 1 activities performed at Site 1 - Former Base Landfill and Oil Pit, included:

- An electromagnetic (EM) geological survey
- Drilling, soil sampling, and abandonment of two soil borings
- Sediment sampling (2 locations)
- Drill, soil sample and install four new monitoring wells
- Sample groundwater at the four new wells (MW-5, MW-6, MW-7, and MW-8) and two previously installed wells (MW-1 and MW-4)
- Aquifer testing using the four new wells.

Locations of field activities for the RI Part 1 at Site 1 is shown in Figure 4-1. A listing of sampling parameters is presented in Table 4-2a.

RI Part 2 activities performed at Site 1 included:

- Drill, soil sample and install five new monitoring wells
- Sample groundwater at the five new wells and six previously installed wells.

Locations of the new monitoring wells (LFW-13, 14, 15, 16, and 17) for Site 1 are also shown in Figure 4-1. A listing of sampling parameters for the RI Part 2 is presented in Table 4-2b.

4.3 SITE HYDROGEOLOGY

The deposits penetrated during drilling at this site ranged widely, from unconsolidated fine to coarse-grained sand to claystone and shale (Figures 4-2, 4-3 and 4-4). An approximate 5-ft thick silt bed, probably loess, was present at the surface throughout the site. Underlying this, coarser-grained sediments appeared in the upper 20 to 25 ft in borings confined primarily to the Tollgate Creek bed, indicating that these are alluvial deposits. Beneath the alluvial deposits in the stream bed and forming the flanks of the valley are principally claystone and shale of the Denver Formation, which existed to depths beyond the depth of drilling at the site.

Static water levels at the site range from 11.6 to 32.7 ft BLS (1/20/89) and from 10.6 to 40.6 ft BLS (8/16/91) and are shallower with proximity to the creek bed. The potentiometric surface maps (Figures 4-5 and 4-6) show that this surface generally mimics surface topography, and groundwater flow is directed from the valley flanks inward and downstream the creek bed. These groundwater-flow patterns indicate that wells LFW-5, 6, and 7 and MW-1 and 2 are upgradient of the landfill; LFW-13, 14, 15, 16 and 17 are downgradient of the landfill; MW-3 and 4 are downgradient of the former tar pit; and LFW-8 is downgradient of the entire site. The hydraulic gradient at the site varies with topography ranging from approximately 0.055 to 0.0088.

Slug testing conducted during the RI Part 1 yielded values of hydraulic conductivity ranging from 1.1×10^{-2} ft/min to 2.1×10^{-2} ft/min. The tests indicate the aquifer in the vicinity well LFW-6 is locally confined. This is further evidenced by examination of the LFW-6 which indicates the well is screened in clay bounded sand bed and the water level is well above levels of saturation seen during well drilling. Logs and slug testing indicate that the aquifer in the vicinity of LFW-6 is confined.

4.4 RESULTS AND SIGNIFICANCE OF FINDINGS

4.4.1 Surface EM Conductivity Survey Results

A surface electromagnetic conductivity survey was conducted during the RI Part 1 at Site 1 to determine the extent of buried landfill material, and the possible location of any buried metal objects (e.g., 55-gal drums). Two secondary magnetic field components were measured and evaluated during the survey at the Base. The quadrature-phase component was used to detect changes in apparent

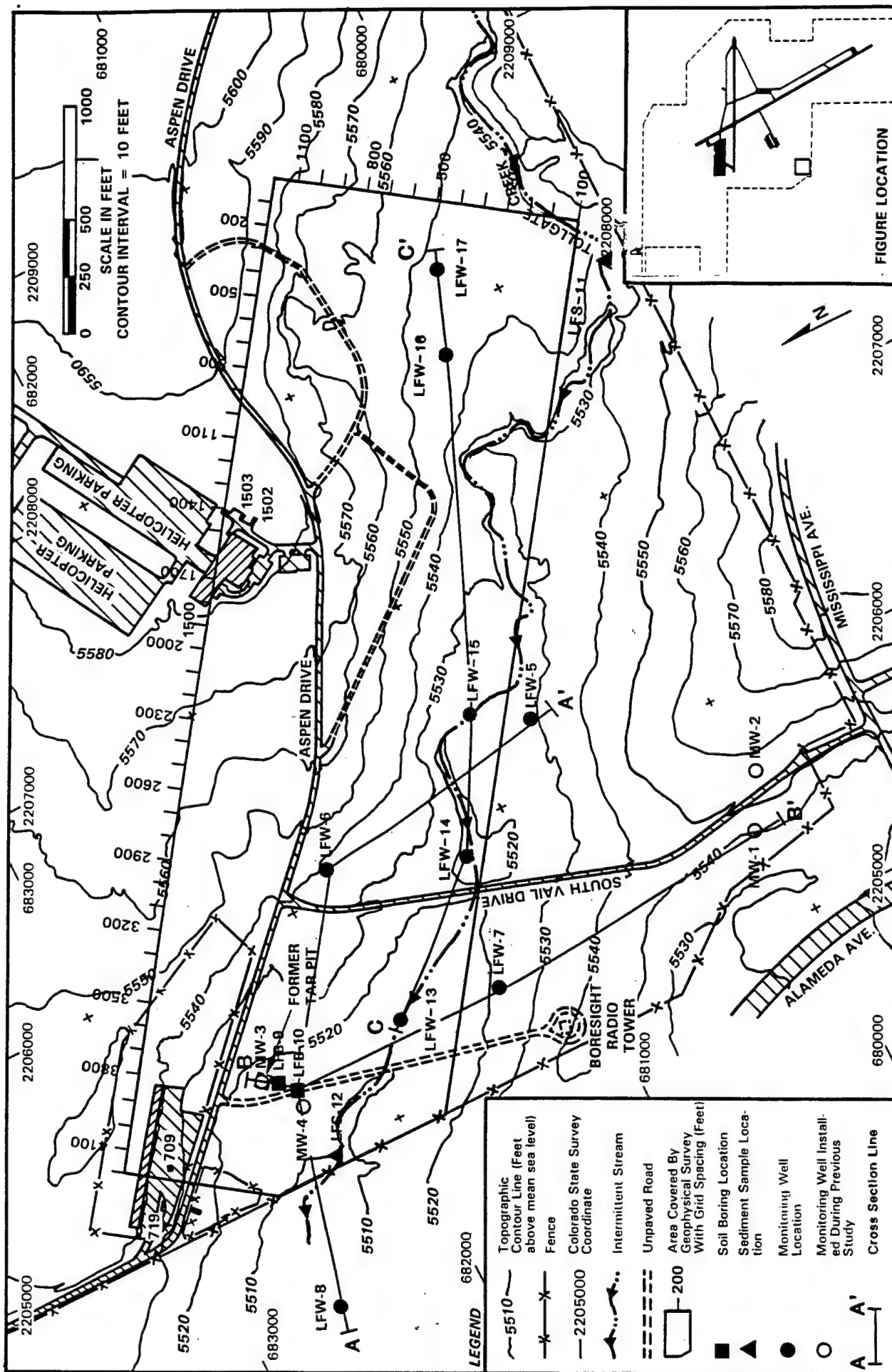


Figure 4-1. Field Activity Locations for Site 1 Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado

TABLE 4-2a. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 1 - FORMER BASE LANDFILL,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

SITE	SAMPLE ACTIVITY/I.D.	ACTIVITY LOCATION	MATRIX	X MOIST	CHEMICAL ANALYSES SAMPLES										GEOTECH (1) SAMPLES	
					VOC	BNA	HERB	PEST	ICP MET	LEAD ONLY	PHOS NIT	ANION CAT				
Soil Boring Boreholes																
	LFB-9	Adj. to Tar Pit	Soil	2	2	2	2	2	2	2	-	-	-	-	-	-
	LFB-10	Adj. to Tar Pit	Soil	2	2	2	2	2	2	2	-	-	-	-	-	-
Monitoring Well Boreholes																
	LFW-5	Up/Cross-gradient	Soil	2	2	2	2	2	2	2	-	-	-	-	3	-
	LFW-6	Up/Cross-gradient	Soil	4	4	4	4	4	4	4	-	-	-	-	-	-
	LFW-7	Up/Cross-gradient	Soil	4	4	4	4	4	4	4	-	-	-	-	3	-
	LFW-8	Downgradient	Soil	4	4	4	4	4	4	4	-	-	-	-	-	-
Groundwater																
	MW-1 (2)	Upgradient	Water	-	1	1	1	1	1	1	-	-	-	1	-	-
	MW-4 (2)	Adj. to Tar Pit	Water	-	1	1	1	1	1	1	-	-	-	1	-	-
	LFW-5	Up/Cross-gradient	Water	-	1	1	1	1	1	1	-	-	-	1	-	-
	LFW-6	Up/Cross-gradient	Water	-	1	1	1	1	1	1	-	-	-	1	-	-
	LFW-7	Up/Cross-gradient	Water	-	1	1	1	1	1	1	-	-	-	1	-	-
	LFW-8	Downgradient	Water	-	1	1	1	1	1	1	-	-	-	1	-	-
Stream Sediment																
	LFW-11	Upstream	Soil	1	1	1	-	-	-	1	-	-	-	-	-	-
	LFS-12	Downstream	Soil	1	1	1	-	-	-	1	-	-	-	-	-	-

(1) - Geotechnical analyses included test for Atterberg limits, grain-size analysis, and vertical permeabilities.

(2) - Monitoring wells installed during a previous study.

TABLE 4-2b. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 1 - FORMER BASE LANDFILL
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 2

SITE	SAMPLE ACTIVITY/I.D	ACTIVITY LOCATION	MATRIX	CHEMICAL ANALYSES SAMPLES						
				VOC	SVOC	HERB	PEST/ PCBs	MET (1)	LEAD ONLY	ASBESTOS
Groundwater										
	MW-1 (2)	Upgradient	Water	1	1	1	1	1	--	1
	MW-4 (2)	Adj. to Tar Pit	Water	1	1	1	1	1	--	1
	LFW-5	Up/Cross-gradient	Water	1	1	1	1	1	--	1
	LFW-6	Up/Cross-gradient	Water	1	1	1	1	1	--	1
	LFW-7	Up/Cross-gradient	Water	1	1	1	1	1	--	1
	LFW-8	Downgradient	Water	1	1	1	1	1	--	1
	LFW-13	Downgradient	Water	1	1	1	1	1	--	1
	LFW-14	Downgradient	Water	1	1	1	1	1	--	1
	LFW-15	Downgradient	Water	1	1	1	1	1	--	1
	LFW-16	Downgradient	Water	1	1	1	1	1	--	1
	LFW-17	Downgradient	Water	1	1	1	1	1	--	1

- (1) - Priority Pollutant Metals plus Arsenic, Antimony, Lead, Mercury, Selenium, Thallium Total (unfiltered) only
(2) - Monitoring wells installed during a previous study

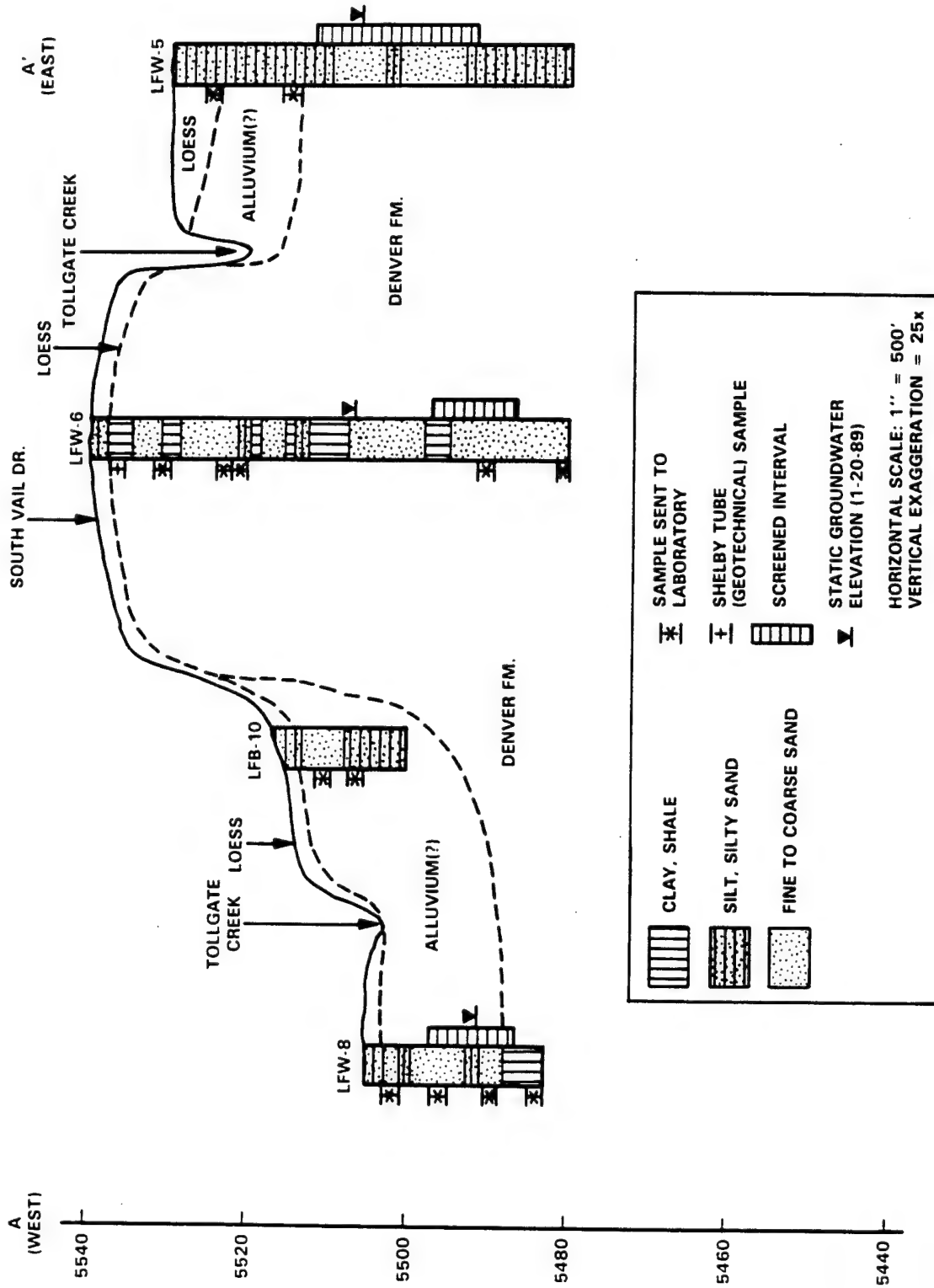


Figure 4-2 Generalized Geologic Profile A-A' of Site-1, Former Landfill Area, Colorado Air National Guard, Buckley Field, Aurora, Colorado.

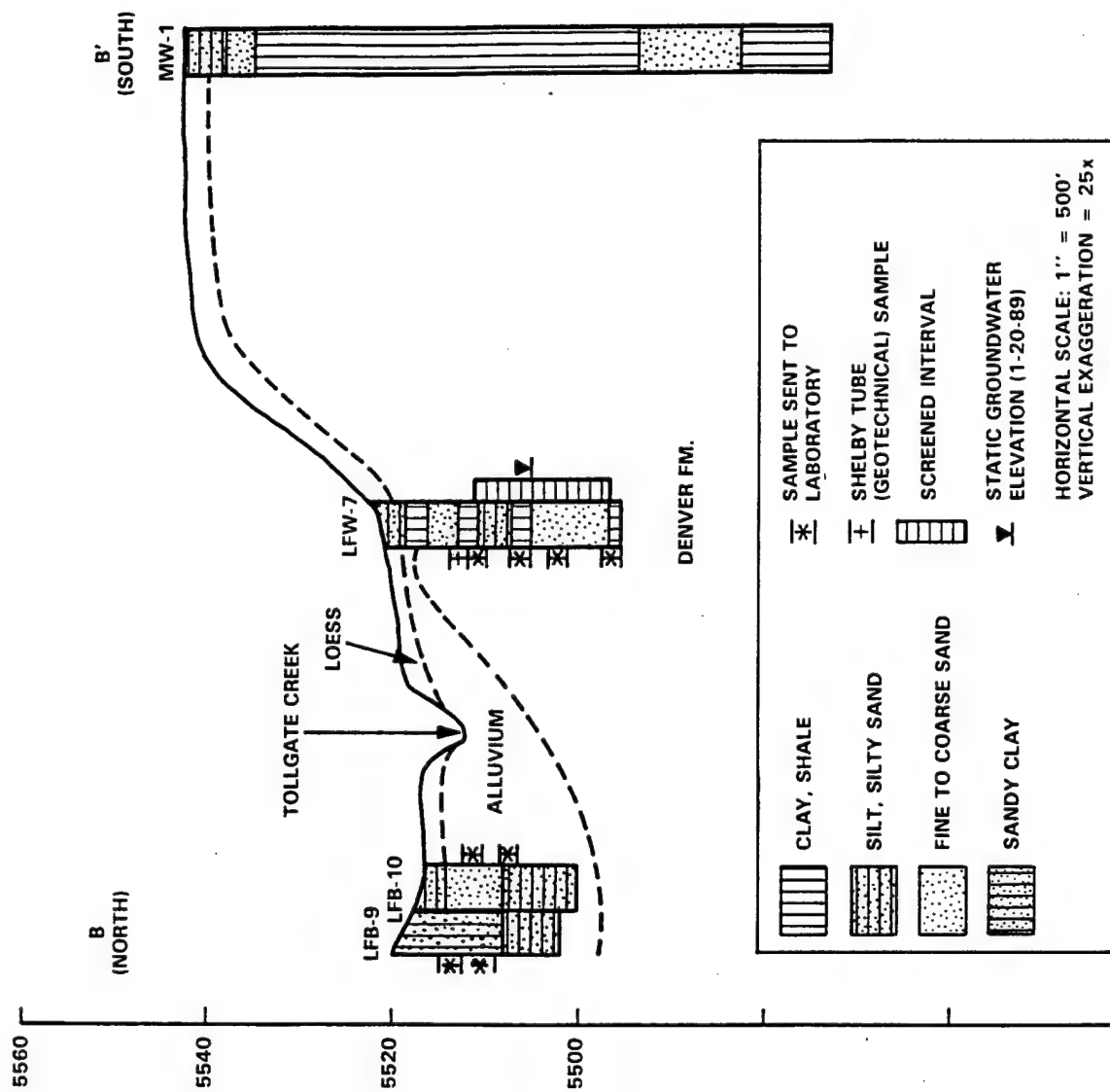


Figure 4-3 Generalized Geologic Profile B-B' of Site-1, Former Landfill Area, Colorado Air National Guard, Buckley Field, Aurora, Colorado.

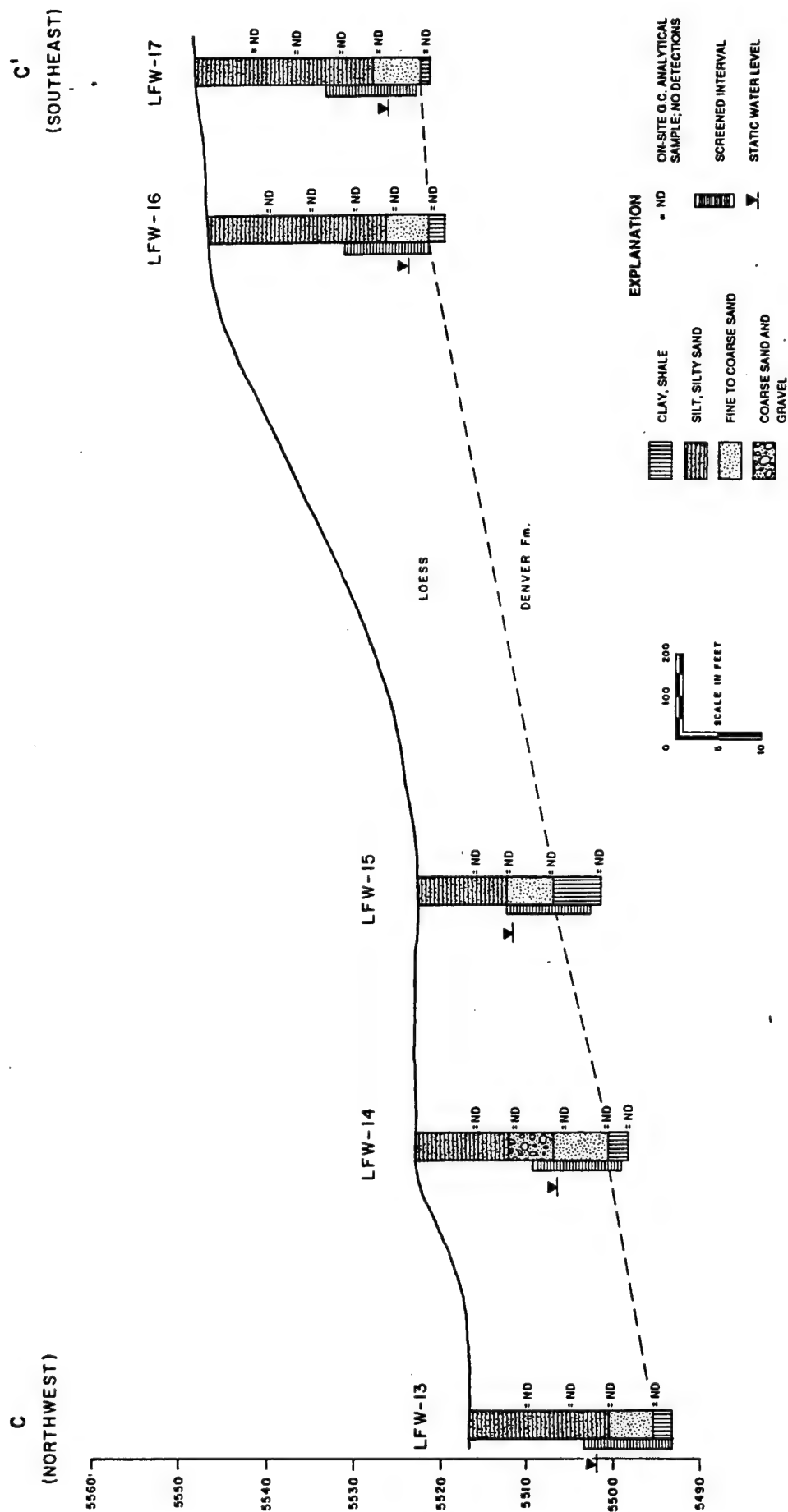


FIGURE 4-4 Generalized Geologic Profile C-C' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil at Site, Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado.

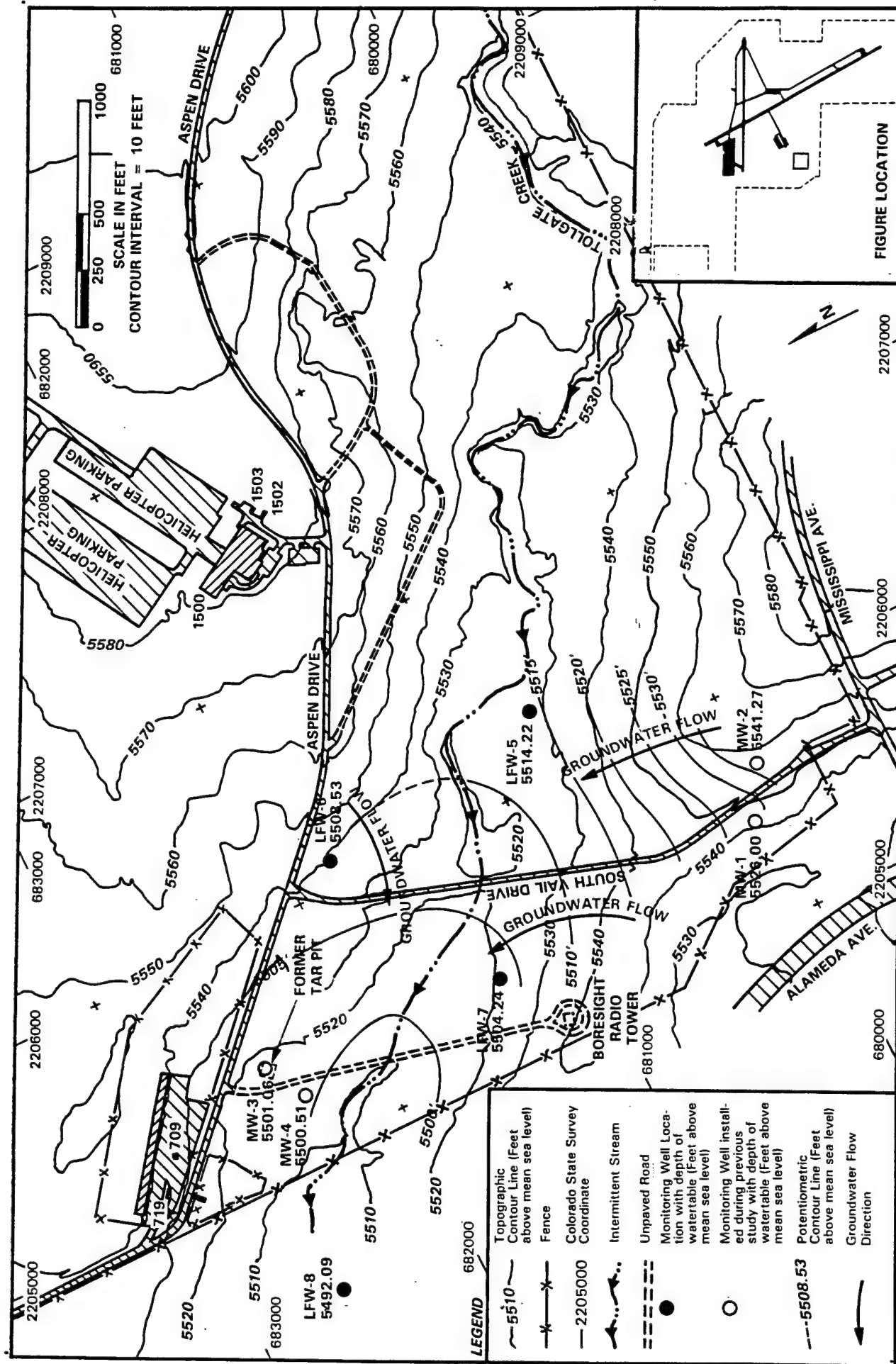
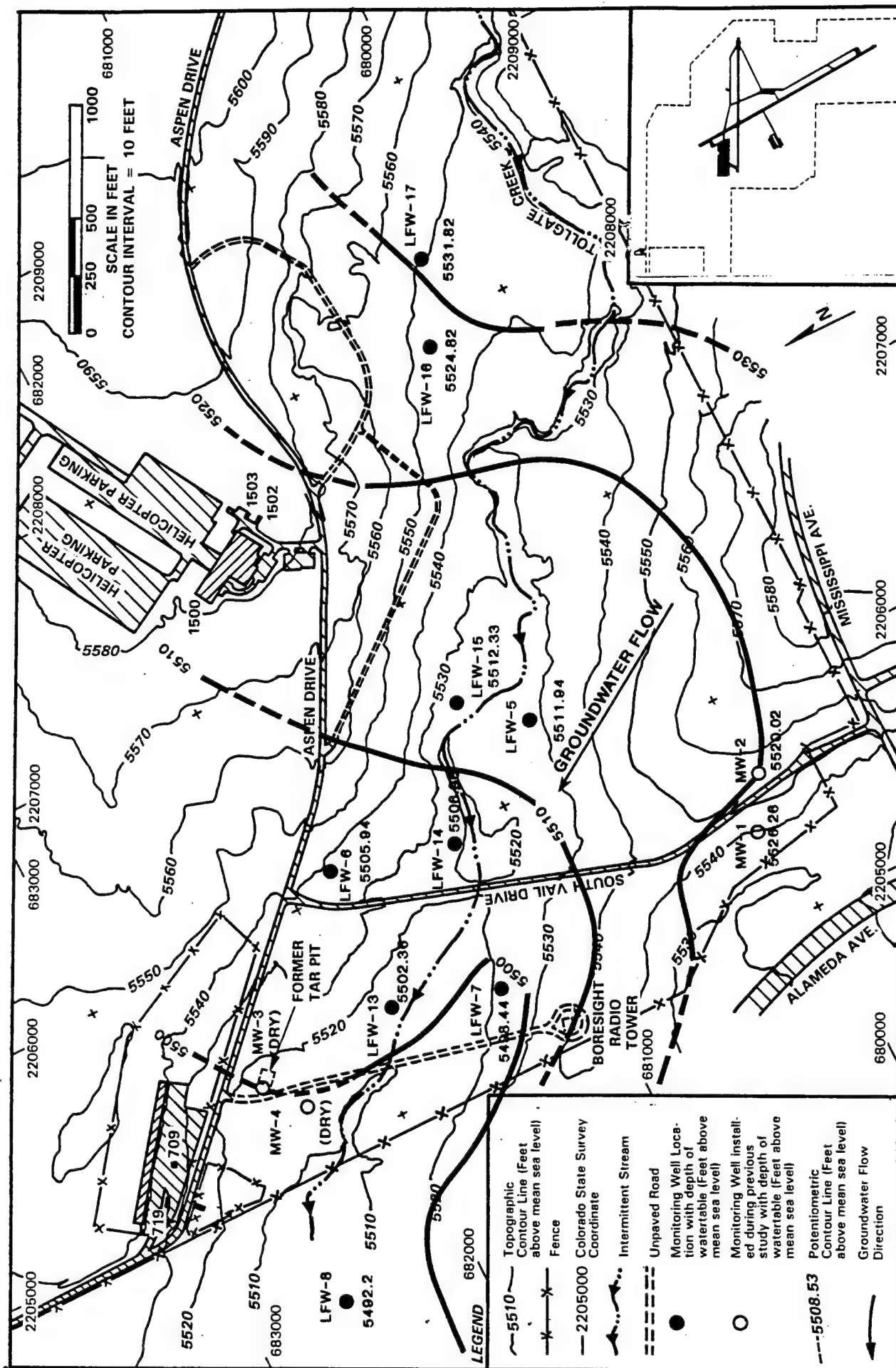


Figure 4-5 Potentiometric Surface Map of Site-1, Former Base Landfill, January 19, 1989, Colorado
Air National Guard, Buckley Field, Aurora, Colorado



conductivity, and the in-phase component was used to detect buried metal objects. Figure 4-1 shows the EM survey grid orientation at Site 1. As seen on the figure, the transect lines are oriented southwest to northeast, with distance along transect line varying from -100 to 1100 ft, and the distance between transect lines varies from 50 to 100 ft over the 4200 ft total length.

Utilities can be detected during an EM survey and must be accounted for during interpretation. Two utilities exist at Site 1, the Former Base Landfill: a water mainline buried on the east side of South Vail Drive and a buried electric line which carries power to the Boresight Radio Tower. The electric line parallels the Base boundary fence on the west side of the site. Both utilities were considered during interpretation.

Lateral variations in soil apparent conductivity were checked by rotating the instrument 90° around a measurement point. These measurements were done at several random points within the site boundaries and showed the soil apparent conductivity to be laterally homogeneous.

Some areas did not indicate true apparent conductivities as evident by negative quantities. Negative quantities are typically caused by edge effects. Edge effects can occur when a vertical contact exists between a good and a poor conductor (such as a buried metal object or a moist clay layer and dry soils), and readings vary quickly with position. Also, edge effects can occur when the dimensions of a good conductor are close to the intercoil spacing of the instrument (McNeill 1984).

Contour plots and profiles of the apparent conductivity data and the in-phase data are included in Appendix E. The contour plots have been filtered during gridding of the data and smoothed during plotting so that large site-wide anomalous trends could be observed and interpreted. The transect profile data which are not filtered or smoothed show more detailed variations along each transect. Analysis of both presentations is necessary for landfill boundary interpretation. Further details of procedures employed during the data acquisition and reduction are discussed in Appendix A.

The apparent conductivity data show a high amount of background variation while the in-phase data are fairly constant over much of the site. These data indicate the background apparent conductivity variations are probably due to changes in the subsurface soil or rock composition, structure, or both. Therefore, a combination of schemes were used to interpret anomalous areas possibly caused by landfill debris. Areas where the apparent conductivity data exceeded the approximate background apparent conductivity of 50 milliSiemens/meter (mS/m), areas that indicated a high amount of variation (± 15 mS/m or greater) within short distances (10 - 20 feet), or areas that showed a high amount of variation continuously over several transects were interpreted as anomalous. Finally, because the in-phase data are not affected by slight changes in ground conductivity, regions with in-phase data variation of 5 parts per thousand (ppt) were interpreted as possible landfill areas.

Examination of the entire data base indicates that a general trend exists over the site: apparent conductivity increases to the south near Tollgate Creek by approximately 10 to 15 mS/m. This increase is most likely due to an increased amount of groundwater in the instrument zone of

penetration along Tollgate Creek. However, the creek edges are also reinforced with riprap in some areas, which also may cause higher apparent conductivity.

The apparent conductivity contour maps show two anomalous regions at Site 1 (Figure 4-7). One region is in the northeast portion of the site (between transects 0100 and 0900). Transect profiles 0000 through 0900 show anomalous data that vary slightly in location depending on the transect, but in general are located between 500 to 1100 ft along each transect. Both the conductivity and in-phase data are anomalous, possibly indicating the presence of landfill debris and buried metal objects. Visible debris (e.g., glass, metal objects, and concrete blocks) was observed on the surface in this area, suggesting that the area was used for landfill activities.

The second anomalous region is in the southwest portion of the site (between transects 2100 to 4100). The apparent conductivity contour plot shows a great deal of variation in anomaly location and strength, especially to the west of South Vail Drive. The in-phase contour plot shows one anomalous area present between transect 2300 and 2800, which corresponds with an apparent conductivity increase in the same location, indicating that a large metal object or objects may be buried in this location. Transect profiles 2200 to 4100 show anomalous conductivity and in-phase data across the site. The locations of anomalous data vary slightly between each transect; however, the anomalies extend continuously over several transects. East of South Vail Drive (transect profiles 2200 to 2800) the conductivity and in-phase data are anomalous from -50 to 500 ft along each profile. West of South Vail Drive (transect profiles 2900 to 4200) the conductivity and in-phase data are anomalous over much of the gridded site. Data from the west of South Vail Drive also show two anomalies to the south of Tollgate Creek which are caused by a drainage line and an electric line, not buried landfill debris. Several areas within this region are only slightly anomalous, while other areas have strong anomalies. These variations indicate that landfill debris may be spread sporadically over this part of the site, causing the complex patterns of apparent conductivity. Debris is also found sporadically over the surface in the second region which further indicates that landfill material has been spread around the site.

Another region at Site 1 exhibited some anomalous characteristics, which may not be caused by buried landfill debris. Transect profiles 1300 to 2100 show short, abrupt apparent conductivity changes, but the variations are not laterally continuous between transects. The in-phase data show little variation along these transect profiles, indicating that no buried metal objects exist in this area, and that the apparent conductivity variations may be caused by something other than buried landfill debris. The area traversed by these transects is covered with surface dirt piles which may have contributed to the conductivity variations because of topographic effects, or the disturbed soil in the piles may have caused anomalously low apparent conductivity results due to air pockets in the soils or a combination of the two.

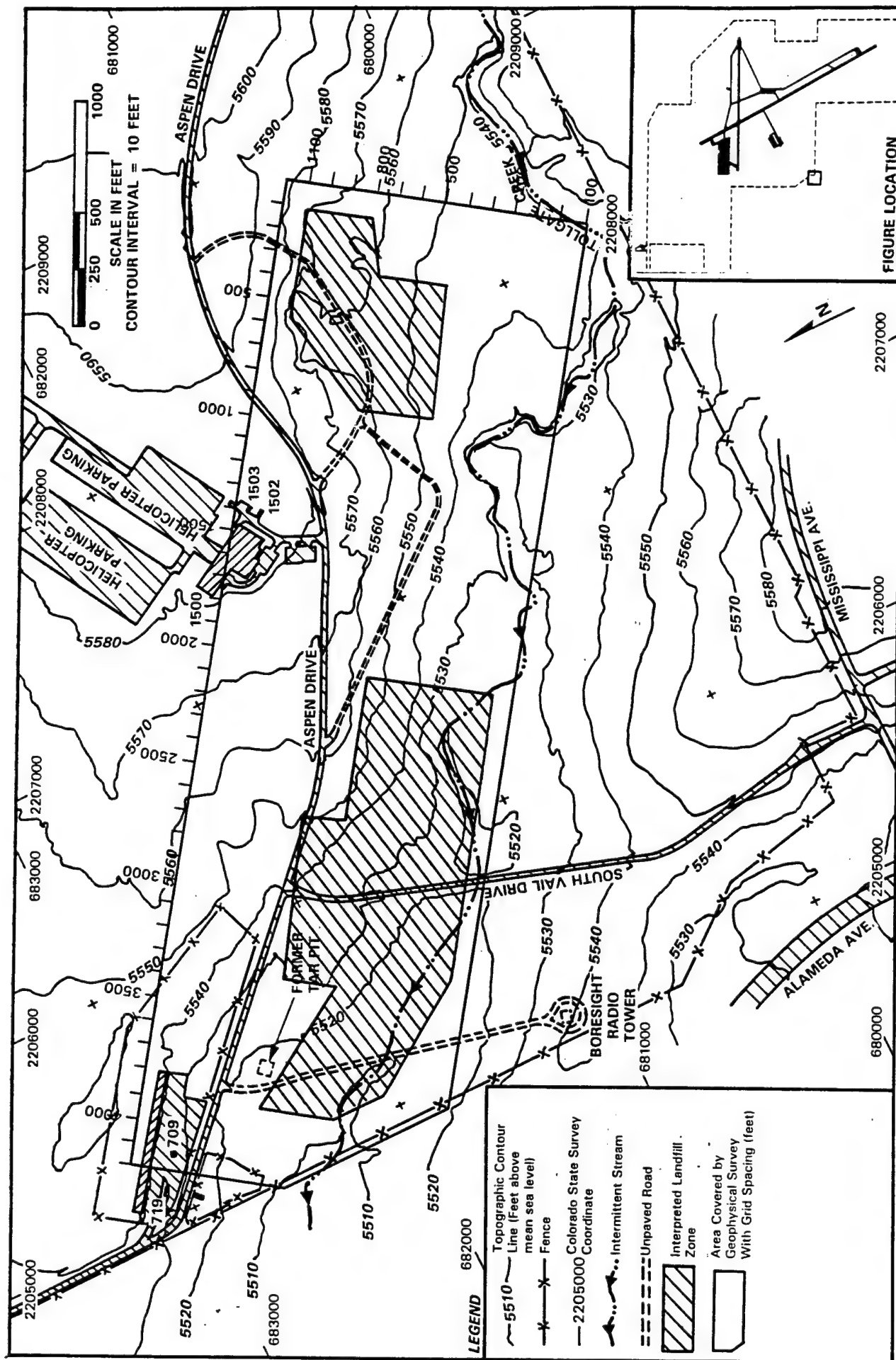


Figure 4-7 Locations of Interpreted Landfill Zone From The Surface E.M. Conductivity Survey at Site-1, Former Base Landfill, Colorado Air National Guard, Buckle Field, Aurora, Colorado

The contour and profile results of conductivity and in-phase data suggest two anomalous regions possibly caused by landfill debris, at the Former Base Landfill Area. Figure 4-7 shows the location of these two suspected areas. The two regions, one to the east of South Vail Drive, and one near the northeast corner of the site, show strong indications of buried metal objects, possibly metal drums. Other anomalous regions were sporadically located throughout the area indicating that landfill operations possibly spread or dumped debris over many parts of the site.

4.4.2 Soil Boring Soil Sample Results

Soil from two borings (LFB-9 and LFB-10) was sampled during the RI Part 1 at Site 1 to determine if soil contamination existed, and to assess possible migration of contaminants deeper into the alluvial aquifer from the Former Oil Pit. Soil samples were collected from 5 and 10 ft below the land surface (BLS), and were sent to the SAIC Environmental Chemistry Laboratory for analyses of parameters as detailed in Table 4-2a. Figure 4-1 shows the location of the two soil borings.

The results from the soil boring samples analyzed during the RI Part 1 are summarized in Table 4-3. Acetone was detected in several samples, but because it was detected in QA/QC samples as well, it is not considered an environmental contaminant at the site. No other volatile or semivolatile organic compounds were detected in either sample from LFB-9. Ethyl benzene (2 µg/kg), styrene (160 µg/kg), and total xylenes (9 µg/kg) were detected in the soil sample from 5 ft BLS in LFB-10. Ethyl benzene and total xylenes were detected at concentrations close to detection limits, but styrene was 1.5 orders of magnitude above the reporting limit. Only styrene was detected in the deeper sample from this borehole (10 ft BLS) at 6 µg/kg. These data indicate that the volatile organic compounds detected in the soil samples are probably not migrating deeply into the alluvium and entering the groundwater below the Former Oil Pit. No chlorinated pesticides or herbicides were detected in the soil-boring soil samples with the exception of the herbicide 2,4-DB, which was detected in the sample from 5 ft BLS in LFB-10 at 140 µg/kg. This herbicide was not detected in the corresponding 10-ft sample, confirming the finding that contaminants are not migrating deeper into the alluvial aquifer at these locations.

All detected levels of priority pollutant metals were either within the 95% CI of the background or within the expected uncontaminated soil range with the exception of mercury, which showed concentrations of 0.28 to 0.29 mg/kg in three samples (LFB-9, 5 ft; LFB-9, 10 ft; LFB-10, 5 ft). The concentrations reported for mercury in these samples are close to the associated detection limits (0.25 mg/kg), and do not show a consistent pattern of environmental contamination. In addition, two different laboratories were used for the sample analysis. The laboratory used for the background sample analysis (i.e., results that would have been used to calculate the 95% CI for the mean background) presented data with reporting limits/order of magnitude below the second laboratory (CENREF). The associated 95% CI of the mean background for mercury calculated from the SAIC data cannot be compared with the CENREF results because of the discrepancy in sensitivity. As a result, mercury concentrations detected close ($\pm 5\%$) to the CENREF reporting units are not considered environmental contamination.

TABLE 4-3. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS IN SOIL SAMPLES AT SITE 1 - FORMER
BASE LANDFILL, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

ANALYTE	UNITS	Sample #:LFB-9(5')			Sample #:LFB-9(10)			Sample #:LFB-10(5)			Sample #:LFB-10(10)			Sample #:LFW-5(5)			Sample #:LFW-5(15)		
		Assoc. QA/QC	Result	Limit	Assoc. QA/QC	Result	Limit	Assoc. QA/QC	Result	Limit	Assoc. QA/QC	Result	Limit	Assoc. QA/QC	Result	Limit	Assoc. QA/QC	Result	Limit
		TB-1	FB-1	EQ-1	TB-1	FB-1	EQ-1	TB-1	FB-2	EQ-2	TB-1	FB-2	EQ-2	TB-1	FB-2	EQ-2	TB-1	FB-2	EQ-2

VOLATILE ORGANICS (Method 8240)																			
Methylene Chloride	ug/Kg	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5
Acetone	ug/Kg	ND	10	38	10	ND	10	ND	10	64	10	ND	10	20	10	ND	10	ND	10
Toluene	ug/Kg	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1
Ethyl benzene	ug/Kg	ND	1	ND	1	2	1	ND	1	ND	1	ND	1	ND	1	ND	1	ND	1
Styrene	ug/Kg	ND	5	ND	5	160	5	ND	5	6	5	ND	5	ND	5	ND	5	ND	5
Total Xylenes	ug/Kg	ND	5	ND	5	9	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5

SEMI-VOLATILE ORGANICS (Method 8270)																			
	ug/Kg	ND		ND		ND		ND		ND		ND		ND		ND		ND	

CHLORINATED PESTICIDES																			
	ug/Kg	ND		ND		ND		ND		ND		ND		ND		ND		ND	

CHLORINATED HERBICIDES																			
2,4-DB	ug/Kg	ND	40	ND	40	140	40	ND	40	ND	40	ND	40	ND	40	ND	40	ND	42

INORGANICS																			

% MOISTURE	wt %	11.3		10.6		9		17.1		15.9		19.2		15.9		19.2		15.9	
ARSENIC	mg/Kg	2.1		1.8		1.4		1.4		1.5		1.3		1.5		1.3		1.5	
BERYLLIUM	mg/Kg	0.5		0.6		0.5		0.8		0.5		0.5		0.5		0.5		0.5	
CALCIUM	mg/Kg	27300		23400		18100		7280		10200		6970		10200		6970		10200	
CHROMIUM, TOTAL	mg/Kg	11.5		9.7		17.8		16.0		13.0		6.4		13.0		6.4		13.0	
COBALT	mg/Kg	5.9		5.4		7.6		8.7		8.4		8.4		8.4		8.4		8.4	
COPPER	mg/Kg	NA		NA		NA		NA		NA		NA		NA		NA		NA	
LEAD	mg/Kg	10.1		16.2		10.8		13.2		13.6		7.2		13.6		7.2		13.6	
MAGNESIUM	mg/Kg	NA		NA		NA		NA		NA		NA		NA		NA		NA	
MERCURY	mg/Kg	0.28		0.29		0.28		ND		ND		0.28		ND		0.28		ND	
NICKEL	mg/Kg	10.4		8.9		11.5		11.8		9.4		8.4		9.4		8.4		8.4	
SELENIUM	mg/Kg	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2	ND	0.2
ZINC	mg/Kg	56		54.7		62.0		69.8		57.1		59.4		57.1		59.4		57.1	

LEGEND

ND- Not Detected
NA- Not Analyzed

4-18

LEGEND

NA- Not Analyzed

Compound was reported present in the laboratory method blank

TABLE 4-3. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS IN SOIL SAMPLES AT SITE 1 - FORMER
BASE LANDFILL, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1 (CONTINUED)

Sample #:LFW-7(18-20)Sample #:LFW-7(24-26)Sample #:LFW-8(4-6) Sample #:LFW-8(8-10)Sample #:LFW-8(15-16)Sample #:LFW-8(20-21)													
		Assoc. OA/OC		Assoc. OA/OC		Assoc. OA/OC		Assoc. OA/OC		Assoc. OA/OC		Assoc. OA/OC	
		TB-3		TB-3		TB-4		TB-4		TB-4		TB-4	
		FB-4		FB-4		FB-5		FB-5		FB-5		FB-5	
		LFW-7EO		LFW-7EO		LFW-8EO		LFW-8EO		LFW-8EO		LFW-8EO	
ANALYTE	UNITS	ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING	
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)													
Methylene Chloride	ug/Kg	16.22 B	6.22	10.19 B	6.18	ND	5.34	ND	5.51	ND	6.15	ND	6.73
Acetone	ug/Kg	ND	124.30	ND	123.62	ND	106.72	ND	110.29	ND	122.91	ND	134.52
Toluene	ug/Kg	ND	6.22	ND	6.18	ND	5.34	ND	5.51	ND	6.15	ND	6.73
Ethyl benzene	ug/Kg	ND	6.22	ND	6.18	ND	5.34	ND	5.51	ND	6.15	ND	6.73
Styrene	ug/Kg	ND	6.22	ND	6.18	ND	5.34	ND	5.51	ND	6.15	ND	6.73
Total Xylenes	ug/Kg	ND	6.22	ND	6.18	ND	5.34	ND	5.51	ND	6.15	ND	6.73
SEMI-VOLATILE ORGANICS (Method 8270)													
	ug/Kg	ND		ND		ND		ND		ND		ND	
CHLORINATED PESTICIDES													
	ug/Kg	ND		ND		ND		ND		ND		ND	
CHLORINATED HERBICIDES													
2,4-DB	ug/Kg	ND	645.5	ND	630.7	ND	530.4	ND	548.6	ND	611.6	ND	671.5
INORGANICS													
% MOISTURE	wt %	20		19		6.1		9		21		26	
ARSENIC	mg/Kg	4.7	0.58	0.95	0.57	2.5	0.5	3.5	0.54	5.8	0.61	1.7	0.65
BERYLLIUM	mg/Kg	0.66	0.18	0.39	0.23	0.52	0.21	0.54	0.22	0.86	0.25	1	0.27
CALCIUM	mg/Kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CHROMIUM, TOTAL	mg/Kg	7.4	3.6	6	4.6	9.4	4.1	7.5	4.3	7.7	4.9	6.4	5.5
COBALT	mg/Kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
COPPER	mg/Kg	21	2.7	13	3.5	15	3.1	14	3.2	27	3.7	42	4.1
LEAD	mg/Kg	10	0.58	6.4	0.57	12	0.5	8.5	0.54	11	0.61	23	0.65
MAGNESIUM	mg/Kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MERCURY	mg/Kg	0.02	0.012	0.02	0.012	0.019	0.01	0.011	0.01	0.015	0.012	0.082	0.013
NICKEL	mg/Kg	9.3	4.5	7.1	5.8	9	5.2	7.7	5.4	41	6.1	ND	6.9
SELENIUM	mg/Kg	0.89	0.58	ND	0.57	ND	0.5	ND	0.54	ND	0.61	ND	0.65
ZINC	mg/Kg	54	0.9	84	1.2	47	1	36	1.1	65	1.2	87	1.4

LEGEND

ND- Not Detected

NA- Not Analyzed

B- Compound was reported present in the laboratory method blank

4.4.3 Monitoring Well Borehole Soil Sample Results

Soil samples were collected and analyzed from four monitoring well boreholes (LFW-5, 6, 7 and 8) during RI Part 1 at Site 1. The objective of the soil sampling in monitoring wells was to provide information about possible contamination existing in the soils and any possible contaminant migration deeper into the alluvial aquifer surrounding the Former Base Landfill. Figure 4-1 shows the locations of these monitoring wells.

Table 4-3 summarizes the data from monitoring well soil samples taken during the RI Part 1 at Site 1. Methylene chloride was detected in several well borehole soil samples; however, methylene chloride is considered a laboratory contaminant and not an environmental contaminant at this site (see Section 2.2.1). Acetone was detected in one well borehole soil sample (LFW-5) at 5 ft BLS. Because acetone was detected in field QA/QC samples as well, it is not considered an environmental contaminant at this site. Ethyl benzene, toluene, and total xylenes (3, 1, and 18 µg/kg, respectively) were detected in LFW-5 from 15 ft BLS at concentrations slightly above reporting limits. No other volatile or semivolatile organic compounds and no chlorinated pesticides or herbicides were detected in any other well borehole soil samples.

Mercury (0.28 mg/kg) was detected in the soil sample from LFW-5 (15 ft) above 95% CI of the mean of the background samples and outside the expected range. However, as discussed in Section 4.4.2, Hg is not considered an environmental contaminant in this soil sample. Selenium (3.9 mg/kg) was detected above the 95% CI of background, and above the expected range for soils in the sample from 60 to 62 ft BLS in LFW-6. Because Se was not detected at elevated concentrations in shallower soils, migration of Se from landfill areas is probably not occurring; selenium may naturally exist at elevated concentrations in these soils. No other priority pollutant metals were detected above the threshold concentration in soil samples from monitoring well boreholes at Site 1 (RI Part 1).

During the RI Part 2 at Site 1, soil samples were collected at 5-ft intervals from the five new monitoring well boreholes (LFW-13, 14, 15, 16 and 17). The objective of the soil sampling in the new monitoring wells was to determine the potential for contaminant migration in the soil emanating from two landfill anomalies identified by the EM conductivity survey performed during the RI Part 1.

Each soil sample was screened on-site by ECS with a Shimadzu 8A GC for toluene, ethylbenzene, xylene, methylene chloride, and TCE. None of these compounds were detected in any of the monitoring well borehole samples at Site 1. The results for the soil samples screened on-site are shown on cross-section C-C' (Figure 4-4). The on-site GC results are also presented in Appendix G-1. Because of the use of on-site GC screening no monitoring well borehole soil samples were sent to NET Pacific for in-depth analysis.

4.4.4 Groundwater Sample Results

During the RI Part 1, two wells installed during the SI Part 1 and four wells installed during the RI Part 1 were sampled. The objective of the groundwater sampling was to determine if the groundwater under Site 1 has been contaminated from chemicals disposed of into the Former Base Landfill.

Table 4-4a summarizes the results from groundwater samples collected during the RI Part 1 at Site 1. Methylene chloride was the only volatile organic compound detected in groundwater samples from Site 1. Methylene chloride, however, is considered a laboratory contaminant and not an environmental contaminant as discussed in Appendix H. Bis(2-ethylhexyl)phthalate was detected in two field samples (MW-1 and MW-4); however, this compound was detected in field QA/QC samples and is not expected to be an environmental contaminant (Appendix H). No other volatile or semivolatile organic compounds were detected in the groundwater samples. No chlorinated pesticides or herbicides were detected at Site 1.

During the RI Part 1 no priority pollutant metals were detected above MCLs except for selenium. Se was detected in four wells above the MCL: MW-1 (260 µg/l), MW-4 (70 µg/l), LFW-7 (120 µg/l), and LFW-8 (19 µg/l). As discussed in Section 4.4.3, Se is also detected in other off-Base surficial aquifer wells near the Base. Apparent elevated Se concentrations may also be an artifact from suspended solids in the groundwater samples. No major cation or anion concentrations except for sulfate. Sulfate was detected in LFW-5 at 718 mg/l (which exceeds State of Colorado drinking water standards), but this concentration is within expected ranges (15 to 1900 mg/l) for groundwater samples in this area as discussed in Section 3.2. Nitrate concentrations were above the MCL in MW-4, and are possibly a result of the sewage leach field near the well. Although no State or Federal drinking water standards exist for calcium, samples from monitoring wells MW-1 and LFW-8 had hardness concentrations 1800 and 2200 mg equivalent CaCO₃/l, respectively, which are considered very hard, but within expected concentration ranges (Hillier et al. 1983).

Specific conductivity and pH were measured for each groundwater sample during the RI Part 1. The specific conductivity varies between 1250 and 7110 µS/cm. No trend was observed, and measured specific conductivity variations may result from the presence of dissolved constituents, which are derived, in part, from dissolution of suspended solids in the water than by in-situ dissolved chemical constituents in the undisturbed groundwater. Sample pH varied from 6.93 to 8.27 (neutral to slightly alkaline). No trends exist which suggest areas where acids or bases are entering groundwater at Site 1.

During the RI Part 2 groundwater samples were collected from six existing wells (MW-1, MW-4, LFW-5, LFW-6, LFW-7, and LFW-8) and the five newly installed monitoring wells (LFW-13, 14, 15, 16 and 17) at Site 1. These additional wells were installed to determine the potential for contaminant migration in the groundwater emanating from two landfill anomalies identified by the EM conductivity survey performed during the RI Part 1. Figure 4-1 shows the locations of all the groundwater monitoring wells at Site 1.

All groundwater samples collected at Site 1, Former Base Landfill, during the RI Part 2 were analyzed in the laboratory (NET Pacific) for VOCs, SVOCs, trace metals, herbicides, and pesticides. Each groundwater sample was also analyzed by Analytica Inc. for asbestos. Table 4-4b summarizes the results from the groundwater samples collected at Site 1 during the RI Part 2. VOC results indicate the presence of 1,2-dichloroethene (17 µg/L) and trichloroethene (11 µg/L) in monitoring well LFW-15. In addition 1,1-dichloroethene (1 µg/L), trichloroethene (1 µg/L), benzene (4 µg/L), toluene (2 µg/L) and chlorobenzene (2 µg/L) were all detected in MW-4. However, these concentrations are considered estimated values. The mass spectral data indicate the presence of compounds that meets the identification criteria for 1,1-DCE, TCE, benzene, toluene and

TABLE 4-4a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES AT SITE 1 - FORMER
BASE LANDFILL, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

ANALYTE	UNITS	Sample #:MU-1				Sample #:MU-4				Sample #:LFU-5				Sample #:LFU-6				Sample #:LFU-7				Sample #:LFU-8			
		Assoc. QA/QC	Result	Limit	Reporting Analysis	Assoc. QA/QC	Result	Limit	Reporting Analysis	Assoc. QA/QC	Result	Limit	Reporting Analysis	Assoc. QA/QC	Result	Limit	Reporting Analysis	Assoc. QA/QC	Result	Limit	Reporting Analysis	Assoc. QA/QC	Result	Limit	Reporting Analysis
FIELD ANALYSIS																									
pH	units	7.83				8.27				7.29				NA				6.93				7.86			
Temperature	deg. C	11.5				12				11.0				12				13				12			
Conductivity	umhos/cm	7110				3170				1250				2070				3920				3360			
VOLATILE ORGANICS (Method 8240)																									
Methylene Chloride	ug/L	ND	5.00	ND	5.00	ND	5.00	ND	5.00	ND	5.00	ND	5.00	ND	5.00	7.27	5.00	ND	5.00	ND	5.00	ND	5.00		
SEMI-VOLATILE ORGANICS (Method 8270)																									
bis(2-ethylhexyl)phthalate	ug/L	21	10	33	10	ND	10	ND	11	ND	11	ND	11	NA				ND	10	ND	10	ND	10		
CHLORINATED PESTICIDES																									
CHLORINATED HERBICIDES																									
INORGANICS																									
ANTIMONY																									
CALCIUM	ug/L	36	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30		
CHLORIDE	ug/L	610000	50	360000	50	320000	50	180000	50	150,000	50	97	0.1	237	0.1	237	0.1	237	0.1	237	0.1	237	0.1		
COPPER	ug/L	494	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30		
FLUORIDE	mg/L	32	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30	ND	30		
LEAD	ug/L	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5		
MAGNESIUM	ug/L	ND	5	16	5	ND	5	ND	5	ND	5	ND	5	NA				ND	5	ND	5	ND	5		
NITRATE	ug/L	640000	200	65000	200	51000	200	20000	200	17,000	200	64000	200	64000	200	64000	200	64000	200	64000	200	64000	200		
NITRITE	mg/L	5.1	53.5	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	ND				9.7	5.3	0.01	0.01	0.01	0.01		
PHOSPHORUS	mg/L	0.5	0.16/0.18	0.04	0.08/0.07	0.04	0.08/0.07	0.04	0.08/0.07	0.04	0.08/0.07	0.04	0.08/0.07	0.09				0.05	0.05	0.01	0.01	0.05	0.05		
POTASSIUM	ug/L	9000	19	790	19	950	19	13000	19	8600	19	8600	19	8600	19	8600	19	8600	19	8600	19	8600	19		
SELENIUM	ug/L	260	2	70	2	ND	2	7.8	2	5.5	2	5.5	2	120	2	120	2	120	2	120	2	120	2		
SODIUM	mg/L	1300000	900	360000	900	130000	900	260000	900	210,000	900	210,000	900	450000	900	450000	900	450000	900	450000	900	450000	900		
SULFATE	mg/L	2950	1110	684	10	13	10	33	10	27	10	27	10	37	10	37	10	37	10	37	10	37	10		
ZINC	ug/L	20	6.8	85	10	13	10	33	10	27	10	27	10	37	10	37	10	37	10	37	10	37	10		

LEGEND
ND- Not Detected
MA- Not Analyzed

Table 4-4b. Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 1 - Former Base Landfill, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2

SAIC ID Number	MW-1-03W	MW-4-03W	LFW-5-02W	LFW-6-03W	LFW-7-02W	LFW-8-02W
Laboratory ID	12165	12124	12141,12149	12125	12126	12150
Collection Date	08/23/91	08/16/91	08/22/91	08/16/91	08/16/91	08/22/91
Associated Field QC Sample	LF-TB11	LF-TB03	LF-TB10	LF-TB03	LF-TB03	LF-TB10
Parameter	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02
Asbestos	F3-EB04	LF-EB03	F3-EB04	LF-EB03	LF-EB03	F3-EB04
Units						
MFL	<0.688	<0.688	<0.688	<0.344	<0.344	<0.688
Trace Metals (SOW 3/90)						
Arsenic	4.9 J(W,B)	5.5 J(B)	3.0 U	3.0 U	3.0 U	3.0 U
Beryllium	2.0 U	2.0 J(B)	2.0 U	2.0 U	2.0 U	2.0 U
Chromium	12.0 U(*)	28.0 J(*)	12.0 U(*)	12.0 U(*)	12.0 U(*)	12.0 U(*)
Copper	19.0 U(*)	64.0 J(*)	20.0 J(B,*)	23.0 J(B,*)	25.0 J(*)	29.0 J(*)
Lead	20.6	23.9	1.9 J(MB,B)	2.2 J(MB,B)	3.3 J(MB)	1.0 J(MB)
Mercury	0.09 J(B)	0.10 J(B)	0.09 U	0.09 U	0.09 U	0.09 U
Nickel	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U
Selenium	246.0 J(N,*)	50.3 J(N,*)	24.3 J(B,N,*)	1.0 UJ(W,N)	94.4 J(N,*)	23.7 J(S,N,*)
Zinc	30.0 J(MB,*)	169.0 J(*)	35.0 J(MB,*)	51.0 J(MB,*)	51.0 J(MB,*)	34.0 J(*)
Volatile Organics (SOW 3/90)						
1,1-Dichloroethene	5 U	1 J	5 U	5 U	5 U	5 U
1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene	5 U	1 J	5 U	5 U	5 U	5 U
Benzene	5 U	4 J	5 U	5 U	5 U	5 U
Toluene	5 U	2 J	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	2 J	5 U	5 U	5 U	5 U
Semivolatile Organics (SOW 3/90)						
bis(2-Ethylhexyl)phthalate	10 U	9 U	17	9 U	9 U	9 U
TIC Total	20 (2)	42 (7)	72 (3)	27 (2)	25 (1)	0 (0)
Pesticides (SW 3550/8080)						
	ND	ND	ND	ND	ND	ND
Herbicides (SW 8150)						
J - estimated value	ND	ND	ND	ND	ND	ND

N - spiked sample recovery outside control limits

S - concentration determined by the method of standard additions

TIC - tentatively identified compound (number of non-TCL compounds detected)

U - compound/element was included in analysis, but was not detected

W - post-digestion spike for GFAA analysis is out of control limit (85-115%), while sample absorbance is less than 50% of spike absorbance

* - duplicate sample analysis results outside of control limit

< - less than the detection limit

B (metals) - the reported value is estimated because it exceeds the instrument detection limit (IDL), but it is below the contract required detection limit (CRDL)

MB - compound also detected in the associated laboratory method blank

ND - is used as a summary result when all compounds/elements were not detected in one analysis

**Table 4-4b. Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 1 - Former Base Landfill,
Colorado Air National Guard, Buckley Field, Aurora, Colorado Remedial Investigation: Part 2 (Continued)**

SAIC ID Number	LFW-13-01W	LFW-14-01W	LFW-15-01W	LFW-15-02W	LFW-16-01W	LFW-17-01W
Laboratory ID	12136	12137	12142	12143	12144	12151
Collection Date	08/20/91	08/20/91	08/21/91	08/21/91	08/21/91	08/22/91
Associated Field QC Sample	F3-TB08 LF-FB01,02 F3-EB03	F3-TB08 LF-FB01,02 F3-EB03	LF-TB09 LF-FB01,02 F3-EB04	LF-TB09 LF-FB01,02 F3-EB04	LF-TB09 LF-FB01,02 F3-EB04	LF-TB10 LF-FB01,02 F3-EB04
Parameter	Units					
Asbestos	MFL	<0.688	<0.688	<0.688	<0.688	<0.688
Trace Metals (SOW 3490)						
Arsenic	µg/L	3.0 U	6.9 B	3.0 U	3.0 U	3.0 U
Beryllium	µg/L	3.0 J(B)	4.0 B	2.0 U	2.0 U	2.0 U
Chromium	µg/L	26.0 J(*)	27.0 J(*)	12.0 U(*)	12.0 U(*)	12.0 U(*)
Copper	µg/L	75.0 J(*)	66.0 J(*)	32.0 J(*)	41.0 J(*)	39.0 J(*)
Lead	µg/L	20.6	29.6	2.4 J(B)	2.0 J(B,W)	8.7
Mercury	µg/L	0.09 U	0.09 U	0.09 U	0.09 U	0.09 U
Nickel	µg/L	18.0 J(B)	22.0 J(B)	16.0 U	16.0 U	16.0 U
Selenium	µg/L	3.6 J(W,N,B,*)	1.0 U(N)	17.3 J(S,N,*)	108.0 J(S,N,*)	120.0 J(S,N,*)
Zinc	µg/L	152.0 J(*)	161.0 J(*)	53.0 (*)	67.0 (*)	63.0 (*)
Volatile Organics (SOW 3490)						
1,1-Dichloroethene	µg/L	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethene	µg/L	5 U	5 U	17	5 U	5 U
Trichloroethene	µg/L	5 U	5 U	11	5 U	5 U
Benzene	µg/L	5 U	5 U	5 U	5 U	5 U
Toluene	µg/L	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	µg/L	5 U	5 U	5 U	5 U	5 U
Semivolatile Organics (SOW 3490)						
bis(2-Ethylhexyl)phthalate	µg/L	31	9 U	9 U	9 U	9 U
TIC Total	µg/L	8 (1)	16 (2)	0 (0)	5 (1)	5 (1)
Pesticides (SW 3550/8080)						
		ND	ND	ND	ND	ND
Herbicides (SW 8150)						
		ND	ND	ND	ND	ND

B(metals) - the reported value is estimated due to the presence of interference

J - estimated value

N - spiked sample recovery outside control limits

S - concentration determined by the method of standard additions

TIC - tentatively identified compound (number of non-TCL compounds detected)

U - compound/element was included in analysis, but was not detected

W - post-digestion spike for GFAA analysis is out of control limit (85-115%), while sample absorbance is less than 50% of spike absorbance

* - duplicate sample analysis results outside of control limit

< - less than the detection limit

B(metals) - the reported value is estimated because it exceeds the instrument detection limit (IDL), but it is below the contract required detection limit (CRDL)

ND - is used as a summary result when all compounds/elements were not detected in one analysis

chlorobenzene- but, the result is less than the sample quantitation limit and greater than zero. No other VOC compounds were detected in the groundwater samples collected at Site 1.

SVOC analyses results indicate the presence of bis(2-ethylhexyl)phthalate in wells LFW-5 and LFW-13 with concentrations of 17 and 31 µg/L, respectively. No other identifiable VOC compounds were detected. SVOC TICs were found in ten groundwater samples submitted for analysis with concentrations ranging from 4 to 72 µg/L. Pesticides, herbicides and asbestos were not detected in any of the groundwater samples submitted for analysis at Site 1 during the RI Part 2.

As in the RI Part 1, no metals were detected above the MCL except for selenium. Estimated values for selenium ranged from 3.6 to 246.0 µg/L in 9 of the 11 monitoring wells sampled at Site 1 during the RI Part 2. As discussed earlier selenium was detected above the 95% CI of background in soil samples analyzed from Site 1 (RI Part 1). These apparently elevated concentrations of selenium in the groundwater at Site 1 may be due to suspended solids (turbidity) in these groundwater samples. In addition, selenium has also been detected in off-Base surficial wells near the base.

Specific conductivity, pH and temperature were measured for each groundwater sample from Site 1 during the RI Part 2 investigation. The specific conductivity varied between 1500 and 6000 umhos and no trend was observed. The specific conductivity variations are probably the result of suspended solids present in these samples. Most samples were cloudy and some were slightly turbid when sampled. Sample pH varied from 6.67 to 7.87 (neutral to slightly alkaline) while sample temperature ranged from 12.7 to 16.8°C. The results of these on-site analyses are consistent with those from the RI Part 1.

4.4.5 Stream Sediment Sample Results

Two stream sediment samples were collected during the RI Part 1 from Site 1 with the objective of determining whether contamination could have been caused by the landfill. LFS-11 was collected upstream from the suspected landfill area to provide background comparison concentrations. LFS-12 was collected adjacent to suspected landfill areas. Locations of the sampling stations are shown in Figure 4-1.

Table 4-5 summarizes the analysis results of stream sediments. Acetone and bis(2-ethylhexyl)phthalate were detected in LFS-12 and the duplicate. These chemicals were also detected in field QA/QC samples and are not considered environmental contaminants at this site (see Appendix H). No other volatile or semivolatile organic compounds, chlorinated pesticides, or herbicides were detected in the sediment samples.

Selenium (3.9 mg/kg) was detected in LFS-11 slightly above the 95% CI of the background and slightly above the expected range for soil samples. The sampling location is upstream from suspected landfill areas which suggests that the Se is not from landfill, but may represent a natural occurrence of Se in this area. Lead was detected in LFS-12 at 63 mg/kg, which is above the 95% CI of the background (10 mg/kg), but not above the expected soil range of 2-200 mg/kg.

TABLE 4-5. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SEDIMENT SAMPLES AT SITE 1 - FORMER
BASE LANDFILL, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

ANALYTE	UNITS	Sample #:LFS-11		Sample #:LFS-12		Sample #:LFS-12(DUP)	
		ANALYSIS RESULT	REPORTING LIMIT	ANALYSIS RESULT	REPORTING LIMIT	ANALYSIS RESULT	REPORTING LIMIT
VOLATILE ORGANICS (Method 8240)							
Acetone	ug/Kg	ND	114.32	197.20	135.32	ND	133.03
SEMI-VOLATILE ORGANICS (Method 8270)							
bis(2-ethylhexyl)phthalate	ug/Kg	ND	387	ND	583	1084	583
CHLORINATED PESTICIDES							
CHLORINATED HERBICIDES							
INORGANICS							
% MOISTURE	wt %	13		26		25	
ARSENIC	mg/Kg	6.3	0.56	4.7	0.64	4.3	0.63
BERYLLIUM	mg/Kg	0.86	0.22	0.72	0.25	0.68	0.27
CHROMIUM, TOTAL	mg/Kg	11	4.5	9.9	5.1	9.6	5.4
COPPER	mg/Kg	23	3.4	22	3.8	22	4.1
LEAD	mg/Kg	21	0.56	63	0.64	62	0.63
MERCURY	mg/Kg	0.028	0.011	0.02	0.013	0.019	0.013
NICKEL	mg/Kg	13	5.6	9.1	6.4	11	6.8
SELENIUM	mg/Kg	3.9	0.56	1.7	0.64	1.1	0.63
ZINC	mg/Kg	52	1.1	68	1.3	70	1.4

LEGEND

ND - Not Detected

NA - Not Analyzed

4.5 SUMMARY OF FINDINGS

Volatile organic compounds were detected in soils above 10 ft BLS in one soil boring (LFB-10), and at 15 ft BLS from one monitoring well (LFW-5). Styrene was detected in LFB-10 at 10 ft BLS, but at low levels. No volatile organic or semivolatile organic compounds were detected deeper than 10 ft BLS, suggesting that migration of these contaminants through the soil is probably not occurring at Site 1. Selenium was detected at 65 ft BLS above the 95% confidence level of local background soils, but shallower soils showed no detectable quantities indicating that this contaminant is probably a natural component of the soil and not from landfill operations.

One stream sediment location (LFS-12) sampled at Site 1 showed concentrations of lead above the 95% confidence interval of the local soil background.

Trichloroethene was detected above the maximum contaminant level (MCL) in LFW-15 during the RI Part 2 and was confirmed in the duplicate sample. Selenium and sulfate were also detected above the MCLs, but were within ranges (Hillier et al. 1983) for the area surrounding the Base. Nitrate was detected at concentrations which exceed MCLs in MW-4. This concentration may be due to the close proximity of a sewage leach field located in the northwestern portion of the site. Elevated concentrations of major cations and anions in the groundwater at Buckley ANGB were observed, which may be caused by the presence of suspended solids in each sample.

4.6 RISK ASSESSMENT RESULTS

4.6.1 Groundwater Consumption Risks

The groundwater consumption risks for Site 1 were computed from data derived from Parts 1 and 2 of this investigation. In order to determine the magnitude of inorganic contamination, Table 4-6 was prepared showing mean and maximum levels of inorganic chemicals in groundwater at this site. For comparison, the applicable or relevant and appropriate requirements (ARARs; i.e., federal and state water-quality criteria and standards) are included. As specified in the Superfund Amendments and Reauthorization Act of 1986 (SARA), on-site remedial actions are required to attain ARARs unless such requirements are formally waived. Referring to Table 4-6, it is observed that the reported levels for nitrate, selenium, and sulfate exceed ARARs. The levels for copper, fluoride, lead, nitrite, and zinc are below ARAR levels. There are no ARARs for TBC guidelines established for antimony, calcium, chloride, magnesium, phosphorus, potassium, and sodium. Therefore, only the three inorganic chemicals exceeding ARARs are included in the risk characterization (see Table 4-7) along with the organic compounds detected.

TABLE 4-8. ARARs FOR INORGANIC CHEMICALS FROM SITE - 1 GROUNDWATER AT THE BUCKLEY ANGB

Inorganic Constituent	Mean Concentration (µg/L)	Maximum Concentration (µg/L)	Drinking (a) Water MCL (µg/L)	Drinking (b) Water MCL (µg/L)	AWQC (c) Adjusted for Drinking Water Only (µg/L)	Federal Water Health Advisories (g)		
						Colorado Drinking Water Standards (µg/L)	One-Day 10 kg (h) (µg/L)	Ten-Day 10 kg (h) (µg/L)
Antimony	8	36		146				
Arsenic	2	7	50		0.0022			
Beryllium	1	4	1	0	0.0068			
Calcium	401,428	740,000						
Chloride	191,000	496,000						
Chromium (k)	13	28	100	100				
Copper	30	75	1,000(e)	1,300(d)	1,000(f)	1,000		
Fluoride	180	500	4,000	4,000		4,000		
Lead	8	30	50	20(d)	50	50		20 µg/day
Magnesium	51,143	77,000						
Mercury	0.07	0.1	2	2	0.144			
Nickel	9	22	100	100	13.4			
Nitrate	11,600	53,500	10,000	10,000(d)		10,000	111,000	111,000
Nitrite	16	60		1,000(d)				
Phosphorous	139	500						
Potassium	5,634	13,000						
Selenium	63	260	10	45(d)	10	10		
Sodium	424,286	1,300,000						
Sulfate	1,294,000	2,950,000	250,000(e)					
Zinc	63	169	5,000(e)		5,000(f)	5,000		

(a) Maximum Contaminant Levels established under the Safe Drinking Water Act.

(b) Maximum Contaminant Level Goal established under the Safe Drinking Water Act.

(c) Ambient Water Quality Criteria established under the Clean Water Act, adjusted for drinking water.

(d) Proposed MCL or MCLG.

(e) Secondary Maximum Contaminant Level (SMCL) established under the Safe Drinking Water Act - not an ARAR.

(f) Criterion established based on taste and odor effects (organoleptic) not human health effects.

(g) Federal Drinking Water Health Advisories are not ARARs, but values to be considered (TBC) in evaluating the significance of observed levels of contamination in drinking water supplies.

(h) Drinking Water Health Advisory for a 10 kg child.

(i) Drinking Water Health Advisory for a 70 kg adult.

(j) Mean concentration of groundwater from Site 1. Mean values were calculated treating "not detected" results as if the subject chemical was present at half the detection limit.

(k) Total chromium, not differentiated by species.

Table 4-7 presents the results of the Site 1 risk assessment for groundwater exposure. The table provides a summary of mean levels of chemical compounds observed in groundwater. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects which was calculated taking into account the calculated dose. The third column described the target organics for potential noncarcinogenic effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual. At this site, risks are characterized separately for exposure to each environmental media: groundwater, soils, and sediments. Risk estimates are not aggregated for simultaneous exposure across media.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

Elevated selenium levels in some of the wells may be attributed to the contribution of suspended solids and the fact that elevated selenium levels (see Section 3.2) are common in this area. The hazard index for selenium at Site 1 is $3.52\text{E-}01$. The occurrence of elevated nitrate levels in MW-4 is probably due to its location relative to a septic tank leach field. The TBC guideline for sulfate is an SMCL that is not enforceable. No health effects data are available for nitrate and sulfate on the IRIS database or in HEAST (1991); therefore, neither a hazard index nor a cancer risk could be computed for these two inorganic chemicals.

Table 4-7 also lists the organic compounds that were detected in groundwater samples collected from Site 1 monitoring wells. The highest concentrations of 1,2-DCE and TCE were detected in well LFW-15. The remainder of the volatile organic compounds were detected in MW-3, all in estimated concentrations below the reporting limits.

As shown in Table 4-7, none of the hazard indices for any subject chemical exceed 1.0. In addition, the hazard index for combined exposure across chemicals is also less than one. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to compounds in groundwater for Base personnel, or for residence hypothetically consuming groundwater off site.

Four potentially carcinogenic chemicals were detected in the groundwater under evaluation. The initial total risk calculation is $2.30\text{E-}05$, above the level where remediation would be considered. However, this value includes a risk estimate from 1,1-DCE. As explained in Table 4-7, 1,1-DCE was estimated in one groundwater sample at $1\text{ }\mu\text{g/L}$, which is below the reporting limit of $5\text{ }\mu\text{g/L}$. Due to the high reporting limit, even calculating the non-detects at one-half the reporting limit computes a mean higher than the 10^{-6} cancer risk level. Therefore, omitting 1,1-DCE from the risk estimate brings the excess lifetime cancer risk combined exposure to $6.3\text{E-}06$. Based on EPA guidelines under CERCLA/SARA, and given the very conservative exposure assumptions used in the assessment, this risk level would be considered to fall within the acceptable range.

Table 4-7. Risk Characterization for Site 1: Groundwater Exposure

COMPOUND	Mean Levels in Groundwater (a) (ug/L)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Nitrate	11,600	No Data Available		
Selenium	65.11	3.52E-01	Hair, Nails	
Sulfate	1,294,000	No Data Available		
ORGANICS				
Benzene	2.58			3.80E-06
bis(2-Ethylhexyl) phthalate	9.71	1.30E-02	Liver	1.60E-06
Chlorobenzene	2.47	1.05E-01	Liver, Kidney	
1,1-Dichloroethylene	2.42	7.00E-03	Liver	1.70E-05
1,2-Dichloroethylene	3.31	4.00E-03	Serum	
Trichloroethylene	2.89			9.00E-07
Toluene	2.47	4.00E-04	Liver, Kidney	
Hazard Index: Combined Exposure		4.80E-01		
Exposure without 1,1-DCE (c)		4.70E-01		
Excess Lifetime Cancer Risk: Combined Exposure				2.30E-05
Exposure without 1,1-DCE (c)				6.30E-06

- Mean of 26 samples. Mean concentrations were determined treating "not detected" results as if the chemical were present at half the detection limit. Concentrations are from on-site monitoring wells, rather than modeled projections.
- Dose calculated assuming ingestion of groundwater and inhalation of volatile organics during showering. Exposure assumptions: EPA Standard Default Factors for groundwater consumption.
- 1,1-DCE was estimated in one groundwater sample at 1 ug/L, which is below the reporting limit of 5 ug/L. Due to the high reporting limit, even calculating the non-detects at one-half the reporting limit computes a mean higher than the 10⁻⁶ cancer risk level. Therefore, the hazard index and cancer risk were also computed without using the 1,1-DCE values.

4.6.2 Soil and Sediment Exposure Risks

Tables 4-8 and 4-9 present the results of the risk assessment for Site 1. The tables first provide a summary of mean levels of chemical contaminants observed in soils and sediments at the sites under investigation. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects which was calculated taking into account the calculated dose. The third column describes the target organics for potential noncarcinogenic effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual. At this site, risks are characterized separately for exposure to each environmental media; soils and sediments. Risk estimates are not aggregated for simultaneous exposure across soils and sediments.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

As shown in Tables 4-8 and 4-9, none of the hazard indices for any subject chemical exceed 1.0. In addition, the hazard indices for combined exposure across chemicals is also less than one. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to compounds in soils or sediments for Base personnel, or for children hypothetically exposed off-site. Only one potentially carcinogenic chemical was detected in the sediments under evaluation. Looking again at the summary tables, it can be seen that the excess lifetime risk of cancer does not exceed 4×10^{-6} at this site. Based on EPA guidelines under CERCLA/SARA, and given the very conservative exposure assumptions used in the assessment, this risk level would be considered to fall within the acceptable range.

4.7 CONCLUSIONS AND RECOMMENDATIONS

Two extremely limited areas (less than 5 ft in thickness) of low concentrations of soil contamination were found at Site 1 (RI Part 1). No VOC soil contamination was detected during the SI. One area was located at the 5- and 10-ft depths of boring LFB-10, which is located adjacent to the tar pit. The second location is the 15-ft depth in the monitoring well borehole LFW-5 adjacent to Tollgate Creek. The low levels of contaminants in both areas consisted principally of hydrocarbons (benzene, toluene, and xylenes) which are related to petroleum (fuel, tar, oil) and the herbicide 2,4-DB in boring LFB-10. Elevated contaminant levels were limited to one or two samples within each borehole and did not show any indication of significant (greater than 10 ft) vertical migration. While mercury and selenium were found in several of the soil samples in borings adjacent to the tar pit, their presence was apparently random.

TABLE 4-8. RISK CHARACTERIZATION FOR SITE 1: EXPOSURE TO SEDIMENTS

COMPOUND	Mean Concentration in Sediment (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)	
INORGANICS					
Arsenic	5.10	3.21E-02	Skin, Lung	4.02E-06	
Beryllium	0.75	9.45E-04	Lung, Skin, Heart		
Cadmium					
Chromium	10.20	1.29E-02	Skin		
Copper	22.00	3.75E-03	GI Tract, Blood		
Lead	48.70	2.19E-01	CNS, Kidney		
Mercury	0.02	4.62E-04	CNS		
Nickel	11.00	3.47E-03	Skin, Lung		
Phosphorous					
Selenium	2.20	4.62E-03	Liver, Kidney, Skin		
Silver					
Thallium					
Zinc	63.00	1.99E-03	Anemia		
ORGANICS					
Ethylbenzene				4.02E-06	
Xylene					
.....					
Hazard Index: Combined Exposure		2.79E-01			
Excess Lifetime Cancer Risk: Combined Exposure		4.02E-06			

- a. Mean of 3 samples. Mean values calculated treating "not detected" results as if the chemical was present at half the detection limit.
- b. Dose calculated assuming ingestion exposure to contaminated sediments in drainage creek offsite. Exposure assumptions: ingestion of 0.50 grams soil per play period each day, by children ages 2 to 6 years, 2 days per week, every week, 9 months per year, for 5 years of a 70 year lifetime. Note data were not obtained for off-site sediment levels. It has been assumed that off-site concentrations at the point of exposure are the same as the observed levels in upstream sediments on-site.

TABLE 4-9. RISK CHARACTERIZATION FOR SITE 1: SOIL EXPOSURE

COMPOUND	Mean Levels in Soil (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic				
Beryllium				
Cadmium				
Chromium				
Cobalt	7.300		Lungs, Skin	
Copper	15.000	1.59E-04	GI Tract, Blood	
Lead				
Mercury				
Nickel				
Phosphorous				
Selenium				
Silver				
Thallium				
Zinc				
ORGANICS				
Acenaphthalene				
Anthracene				
Ethylbenzene	0.002	7.85E-09	Skin, Liver, Kidney	
Fluorene				
2-Hexane				
Methylene Chloride				
2-Methylnaphthalene				
Naphthalene				
Nitrobenzene				
N-Nitrosodiphenylamine				
Phenathrene				
Styrene	0.042	8.22E-08	Liver, Blood	
1,1,2,2-Tetrachloroethane				
Tetrachloroethylene				
Toluene				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Trichloroethylene				
Xylenes	0.006	1.26E-09	CNS	

Hazard Index: Combined Exposure		1.59E-04		
Excess Lifetime Cancer Risk: Combined Exposure				

- a. Mean of 4 samples. Mean concentrations were determined treating "not detected" results as if the chemical was present at half the detection limit.
- b. Dose calculated assuming ingestion exposure to contaminated surface soil on-site.
Exposure assumptions: inadvertent ingestion of 0.1 grams of soil/day, by Base personnel: 70 kg adult exposed 2 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

Further, the concentrations found were close to background levels and cannot be linked to any disposal activity in the landfill vicinity.

Limited groundwater contamination was detected at Site 1 during RI that was not detected during the SI. Trichloroethene exceeding the MCL (5 µg/L) and low levels of 1-2 Dichloroethene were detected in LFW-15. In addition, low levels of bis(2-ethylhexyl)phthalate were detected in LFW-5 and LFW-13. Several inorganic compounds were detected within these groundwater samples, but levels are consistent with natural background levels. Stream-sediment samples collected at the site show no evidence of site-related sediment contamination related to site surface and groundwater discharges into the stream bed. Again, several inorganic compounds were found within these samples but are consistent with natural background levels.

Because of various activities including the 13 monitoring wells located at up-, cross-, and downgradient groundwater locations at the site, the drilling of three soil borings, and sampling of the stream sediments, the landfill has been adequately monitored to detect any major contamination problem. Results have shown no definite stream sediment contamination, low levels of apparently random, extremely limited subsurface soil contamination and limited groundwater contamination in LFW-15. The variability of the sediment analyses does not eliminate the possibility of minor contamination. If the Department of Defense funding priorities permit, the sediment will be more adequately defined.

A baseline public health risk assessment indicated that there is no significant carcinogenic or noncarcinogenic risk associated with the presence of this limited soil and groundwater contamination at the site. However, since trichloroethene groundwater contamination is present in LFW-15 a long-term groundwater monitoring plan is proposed. The long-term monitoring plan would consist of sampling LFW-15 and the existing downgradient monitoring network (wells LFW-5, LFW-14, LFW-13, and LFW-8) in order to determine the potential for contaminant migration.

5.0 SITE 2 - FORMER FIRE TRAINING AREA #1

This section provides information specifically pertaining to Site 2. This includes past investigation activities, remedial investigation (RI) objectives and activities performed, the results and significance of RI findings, risk assessment results, and conclusions and recommendations. Background information of past activities is provided in Sections 5.1 and 5.2. A complete description of activities and results of IRP Phase II, Stage 1, Part 1 are presented in "Installation Restoration Program, Phase II-Confirmation/ Quantification Stage 1, Buckley Air National Guard Base" (Dames & Moore 1986).

5.1 SITE DESCRIPTION AND PREVIOUS WORK

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley ANGB and to assess potential for contaminant presence and migration. This phase consisted primarily of interviews and record review.

The precise location of FTA No. 1 has been uncertain. Previous studies suggested that the site was located south and west of the surface reservoir located in the northeast corner of the base. Interviews with the Base Fire Chief during preparation of the work plan for this RI effort suggest, however, that the site is located southeast of the reservoir, which is used as water storage for fire fighting and for recreational fishing (Simons, Li, & Associates, Inc. 1982; Butler 1988). This second area was the focus of this RI study. FTA No. 1 was unlined and undiked and used as an AVGAS burning site during the late 1940s and early 1950s. The frequency of training exercises at the site is unknown. Residual flammable materials may be present on the site. A "firing-in" range for alignment of aircraft guns once occupied the site; an aircraft engine test facility is currently located there.

IRP Phase II, Stage 1, Part 1, Confirmation/Quantification (Site Inspection)

Field investigations were conducted at Site 2. Activities included drilling, sampling and logging of two soil borings. Chemical analyses of soil samples was performed. However, in light of the misinformation on the site location upon which this study was performed, results can be considered indicative of background conditions at this site.

With the possible exception of lead concentrations, previous chemical analyses of soils from near this site (see Table 5-1) indicated that no contamination was present. The analytical results for lead, although indicating evidence of contaminant levels, were inconclusive due to matrix interferences in the test procedure.

The Site Inspection did not investigate the correct location of the site; therefore, did not determine background contaminant concentrations, or confirm the presence and extent of lead or other chemicals at the site. Other information identified for this final RI to complete data gaps included determining the precise location of the site, downgradient contaminant concentrations, the extent of contamination, and defining the hydrogeologic properties of the underlying strata. Recommendations for further investigation included installing one downgradient well at FTA No. 1 (Site 2).

TABLE 5-1. ANALYTICAL RESULTS FOR SITE 2—FORMER FIRE TRAINING AREA NO. 1

Parameter (Sample Depth-Feet)	Method	Unit	Detection Limit	SOIL SAMPLES			
				B-1 (0-1.5)	B-1 (5-6.5)	B-2 (0-15)	B-2 (5-6.5)
Lead	239.1 ^a	mg/kg	10	34	34	44	31
Phenolics	420.2 ^a	mg/kg	1	7	10	1	ND
Total Organic Carbon	415.1 ^a	mg/kg	5	2200	1100	4900	2600
Total Organic Halocarbons	9020 ^b	mg/kg	5	ND	ND	ND	ND
Moisture Content	160.3 ^a	Percent	1	13	11	6	13

^a Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

^b Test Methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, Modified for use on 0.1. Corp. Model 610 TOX Analyzer. ND - indicates value less than detection limits. Source: Dames & Moore, 1986 and 1987. "Installation Restoration Program, Phase II—Confirmation/Quantification, Stage 1."

5.2 REMEDIAL INVESTIGATION ACTIVITIES

Remedial Investigation activities were based upon findings of the Preliminary Assessment (Phase I Records Search) and two site inspections (Phase II Stage 1, Parts 1 and 2-Confirmation/Quantification). Objectives of the RI were to:

- Determine if contamination of the various environmental media at Site 1 is present
- Identify the source(s) and nature of contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risk any present contamination may pose to public health, thereby determining the need for remedial actions.

RI Part 1 activities performed at Site 2-Former Fire Training Area No. 1, included:

- Conducting a soil-gas survey
- Drill, soil sample, and install one monitoring well
- Sample groundwater at the one well
- Aquifer test the one well.

Locations of field activity for Site 2 are shown in Figure 5-1. A listing of sampling parameters is presented in Table 5-2. No additional field work was performed during the RI Part 2 at Site 2.

5.3 SITE HYDROGEOLOGY

Only one groundwater monitoring well (F1W-3) was installed at this site. A surficial 2-ft layer of silt is probably of eolian origin. The lithology below this layer consisted of silty clay to coarse gravelly sand, probably alluvial deposits. Clay layers in the portion of this sand deposit probably belong to the Denver Formation.

The static water level within this well was 9.1 ft BLS, the shallowest on the Base. A potentiometric surface map cannot be drawn on the basis of one well. However, based upon the 5529 ft MSL level of the nearby reservoir and basewide trends, the probable groundwater flow direction is toward the reservoir with a gradient which approximates topography. Therefore, well F1W-3 is downgradient of the location of the former burn pit thought to be underneath the present Power Check Pad. The fact that this water table may be perched is a strong possibility based upon the shallower-than-expected water table and the presence of a basal clay layer underneath the coarse-grained, shallow, water bearing strata.

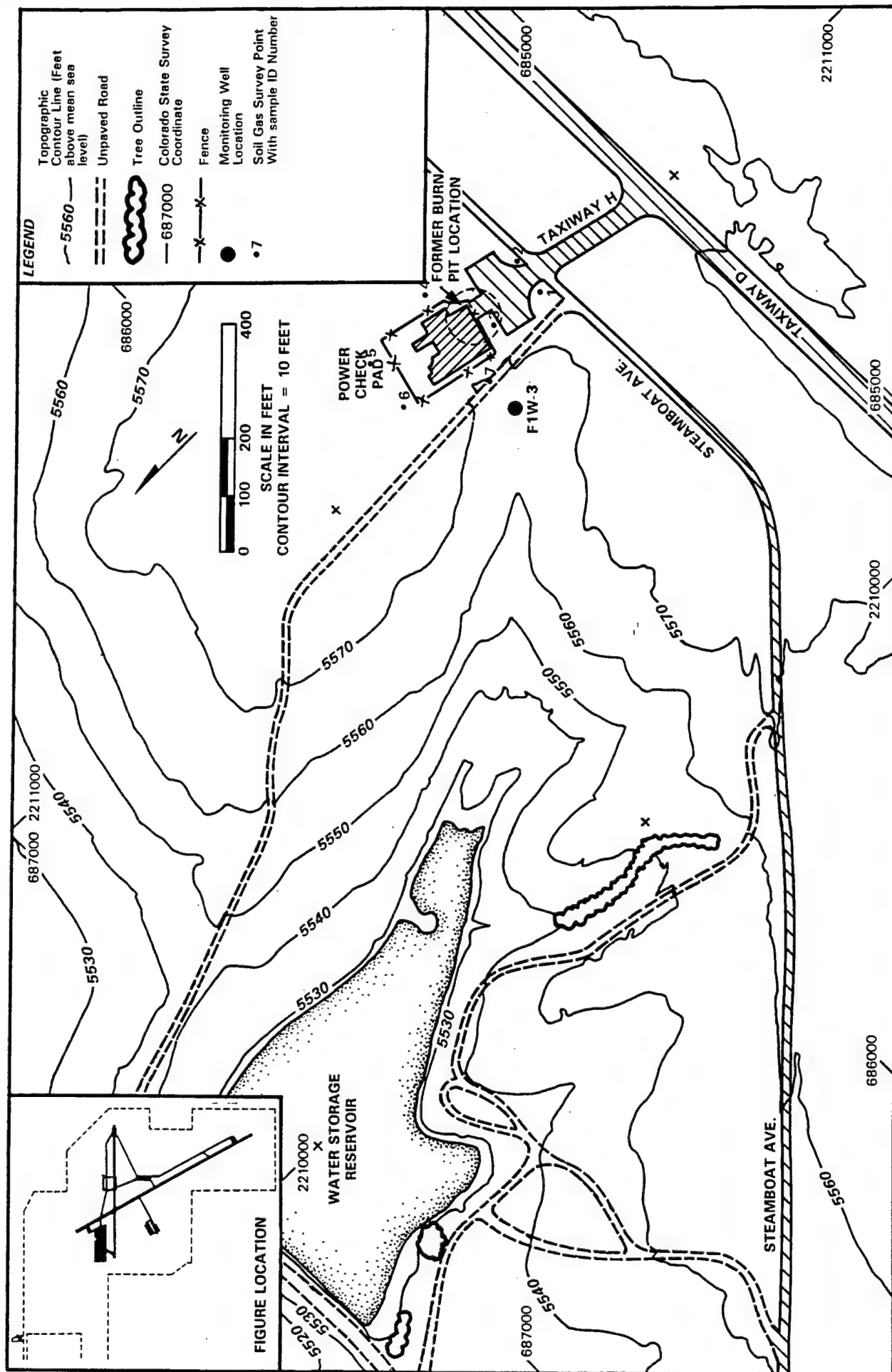


Figure 5-1 Field Activity Locations for Site 2- Former Fire Training Area No. 1, Colorado Air National Guard, Buckley Field, Aurora, Colorado

TABLE 5-2. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 2 - FORMER BASE FIRE TRAINING AREA NO. 1,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO

SITE	SAMPLE ACTIVITY/I.D.	ACTIVITY LOCATION	MATRIX	CHEMICAL ANALYSES SAMPLES										GEOTECH (1) SAMPLES	
				% MOIST	VOC	BNA	HERB	PEST	ICP MET	LEAD ONLY	PHOS NIT	ANION CAT			
Monitoring Well Boreholes															
	F1W-3	Downgradient	Soil	4	4	1	-	-	-	4	-	-	3		
Groundwater															
	F1W-3	Downgradient	Water	-	1	1	-	-	1	-	-	1	-		

(1) - Geotechnical analyses included test for Atterberg limits, grain-size analysis, and vertical permeabilities.

Slug testing yielded a value of hydraulic conductivity of 2.0×10^{-2} ft/min. The test also supported logs in determining that the aquifer in this area is unconfined.

5.4 RESULTS AND SIGNIFICANCE OF FINDINGS

5.4.1 Soil-Gas Survey Results

Seven samples were collected and analyzed during the RI Part 1 at Site 2, Fire Training Area 1. Samples were analyzed for volatile halocarbons and total hydrocarbons (inclusive of C^1 to C^{10} aliphatic and aromatic hydrocarbons). The location of soil-gas sampling points is shown in Figure 5-1. The samples were collected on a grid surrounding the Power Check Pad, which is the suspected location of Fire Training Area 1. The samples were collected from approximately 6 ft BLS. Details of the soil-gas procedures are discussed in Section 2.2.1, and the raw soil-gas data are included in Appendix F.

Halocarbon analysis showed only two sampling locations with concentrations of 1,1,1 TCA and PCE (0.01 and 0.02 $\mu\text{g/l}$, respectively) one to two orders of magnitude above ambient air background levels. However, while these concentrations are higher than ambient background, they are extremely low relative to expected levels if subsurface contamination were present, and they do not definitively support the presence of contaminants in the subsurface. No total hydrocarbons were found above sample detection limits in the ambient air or in the subsurface. No trends were observed with either TCA or PCE; therefore, no source area or contaminant plume was detected.

5.4.2 Monitoring Well Borehole Soil Sample Results

During the RI Part 1, four soil samples were collected from monitoring well F1W-3 for analysis. The objective of soil sampling was to determine if any contamination exists in the soil and to assess possible contaminant migration deeper into the alluvial and Denver Aquifers. Figure 5-1 shows the location of the monitoring well at Site 2.

Table 5-3 summarizes the soil sample data from F1W-3. The only volatile organic compound detected was methylene chloride. However, methylene chloride is a laboratory contaminant (Appendix H) and is not considered to be indicative of environmental contamination at this site. No semivolatile organic compounds were detected. Lead was detected above the 95% CI of the background, but in concentrations (3.3 to 15 mg/kg) within expected background concentration range (Table 3-4).

5.4.3 Groundwater Sample Results

Table 5-4 summarizes the RI Part 1 groundwater sample results from F1W-3. No volatile or semivolatile organic compounds were detected. No lead was detected. Calcium, magnesium, potassium, sodium (major cations), and chloride, fluoride, nitrate, nitrite, phosphorous, and sulfate (major anions) were all detected within concentration ranges typical of Denver Aquifer near the Base (Hillier et al. 1983). Water hardness was 900 mg equivalent CaCO_3/l , which is within expected ranges (Hillier et al. 1983). Fluoride (2.69 mg/l), nitrate (10.1/9.22 mg/l), and sulfate (1050 mg/l) were all detected at higher concentrations than water-quality criteria established by the State of

Table. 5-3 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 2- FORMER
FIRE TRAINING AREA NO 1, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE	UNITS	Sample #: FIW-3(0-2)				Sample #: FIW-3(4-6)				Sample #: FIW-3(8-10)				Sample #: FIW-3(11-13)			
		ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)																	
Methylene Chloride	ug/Kg	26.12 B	5.46	28.57 B	5.70	17.00 B	6.04	16.78 B	5.80								
SEMI-VOLATILE ORGANICS (Method 8270)																	
INORGANICS																	
% MOISTURE	wt %	8		14		16		14									
LEAD	mg/Kg	15	0.54	9.4	0.59	3.3	0.59	3.7	0.57								

LEGEND

- ND- Not Detected
B- Compound was reported present in the laboratory method blank
NA- Not Analyzed

Table. 5-4 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES AT SITE 2- FORMER
FIRE TRAINING AREA NO 1, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE		UNITS	ANALYSIS REPORTING RESULT LIMIT	Sample #:FIW-3 Assoc. QA/QC
.....				
FIELD ANALYSIS				
pH	units	7.22		
Temperature	deg. C	13		
Conductivity	umhos/cm	2872		
VOLATILE ORGANICS (Method 8240)				
			ND	
SEMI-VOLATILE ORGANICS (Method 8270)				
			ND	
INORGANICS				
CALCIUM	ug/L	180000	50	
CHLORIDE	mg/L	43	0.1	
FLOURIDE	mg/L	2.69	0.05	
MAGNESIUM	ug/L	110000	200	
NITRATE	mg/L	10.07/9.2	0.01	
NITRITE	mg/L	ND	0.01	
PHOSPHOROUS	mg/L	0.08	0.03	
POTASSIUM	ug/L	2100	19	
SODIUM	mg/L	350000	900	
SULFATE	mg/L	1050	0.2	

LEGEND

ND- Not Detected

Colorado (Colorado Department of Health 1971) or the maximum contaminant levels (MCLs) established in the federal Safe Drinking Water Act. Sulfate has been detected at concentrations above the MCL in other wells near the Base as discussed in Section 3.2. However, the sample contained suspended solids which may have caused higher concentrations of sulfate and other anions detected in the sample.

Specific conductivity and pH were measured for the water sample collected at F1W-3. Specific conductivity was measured at 2872 $\mu\text{S}/\text{cm}$. While this value is twice the background level, it is consistent with values measured in groundwater samples elsewhere on the base and could possibly be caused, in part, by dissolution of the suspended solids in the sample. The pH is near neutral and is also near background levels.

5.5 SUMMARY OF FINDINGS

The soil-gas survey and analysis of soil samples do not indicate the presence of environmental contamination due to previous fire-training exercises. No analytes detected in the groundwater were above MCLs except for some major ions (e.g., calcium, sulfate).

5.6 RISK ASSESSMENT RESULTS

5.6.1 Groundwater Consumption Risks

In order to examine the magnitude of this contamination a summary table, Table 5-5, has been prepared showing mean and maximum levels of inorganic toxicants in groundwater at Site 2. Since no detectable quantities of organic substances were detected, there are no ARAR tables for that type of contaminant. For comparison, the applicable or relevant and appropriate requirements (ARAR; i.e., federal and state water-quality criteria and standards) are included. As specified in the Superfund Amendments and Reauthorization Act of 1986 (SARA), on-site remedial actions are required to attain ARARs unless such requirements are formally waived. Referring to Table 5-5, it can be observed that the reported levels for nitrate and sulfate exceed ARARs and/or TBC guidelines. The TBC guideline for sulfate is an SMCL that is not enforceable and is set based on secondary (non-health-related) criteria. The concentration of nitrate is only slightly above the MCL. The concentrations of fluoride and nitrite are below established ARAR levels or TBC guidelines. There are no ARARs or TBC guidelines for calcium, chloride, magnesium, phosphorous, potassium, and sodium. Since all detected quantities of organic and inorganic compounds are below ARAR levels or TBC guidelines or there is a reasonable explanation (not related to hazardous material disposal or handling practices) for the occurrence of elevated levels, a risk characterization was not conducted for the groundwater-consumption pathway.

5.6.2 Soil and Sediment Exposure Risks

Table 5-6 presents the results of the risk assessment for Site 2 soils. The table first provides a summary of mean levels of chemical contaminants observed in soils and

TABLE 5-5. ARARS FOR INORGANIC CHEMICALS FROM SITE 2 GROUNDWATER AT THE BUCKLEY ANG8

Inorganic Constituent	Mean Concentration (ug/L)	Maximum Concentration (ug/L)	Drinking (a)		Drinking Water MCLG (ug/L)	Adjusted for Drinking Water Only (ug/L)		Federal Water Health Advisories (g)	
			MCL (ug/L)	Water (ug/L)		Only (ug/L)	Colorado Drinking Water Standards (ug/L)	One-Day (h) 10 kg (ug/L)	Ten-Day (h) 10 kg (ug/L)
Calcium	180,000	180,000							
Chloride	43,000	43,000							
Fluoride	2,690	2,690	4,000		4,000		4,000		
Magnesium	110,000	110,000							
Nitrate	10,070	10,070	10,000		10,000 (d)		10,000	111,000	111,000
Nitrite	5	5			1,000 (d)				
Phosphorous	80	80							
Potassium	2,100	2,100							
Sodium	350,000,000	350,000,000							
Sulfate	1,050,000	1,050,000	250,000 (e)						

(a) Maximum Contaminant Levels established under the Safe Drinking Water Act.

(b) Maximum Contaminant Level Goal established under the Safe Drinking Water Act.

(c) Ambient Water Quality Criteria established under the Clean Water Act, adjusted for drinking water.

(d) Proposed MCL or MCLG.

(e) Secondary Maximum Contaminant Level (SMCL) established under the Safe Drinking Water Act - not an ARAR.

(f) Criterion established based on taste and odor effects (organoleptic) not human health effects.

(g) Federal Drinking Water Health Advisories are not ARARs, but values to be considered (TBC) in evaluating the significance of observed levels of contamination in drinking water supplies.

(h) Drinking Water Health Advisory for a 10 kg child.

(i) Drinking Water Health Advisory for a 70 kg adult.

(j) Since one sample was taken from only one well the mean and the maximum were assumed to be the reported values for that one particular well.

Table. 5-6 RISK CHARACTERIZATION FOR SITE 2: SOIL EXPOSURE

COMPOUND	Mean Levels in Soil (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic				
Beryllium				
Cadmium				
Chromium				
Copper				
Lead	12.00	3.36E-03	CNS, Kidney	
Mercury				
Nickel				
Phosphorous				
Selenium				
Silver				
Thallium				
Zinc				
ORGANICS				
Acenaphthalene				
Anthracene				
Ethylbenzene				
Fluorene				
2-Hexane				
Methylene Chloride				
2-Methylnaphthalene				
Naphthalene				
Nitrobenzene				
N-Nitrosodiphenylamine				
Phenathrene				
1,1,2,2-Tetrachloroethane				
Tetrachloroethylene				
Toluene				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Trichloroethylene				
Xylenes				

Hazard Index: Combined Exposure		3.36E-03		
Excess Lifetime Cancer Risk: Combined Exposure				

a. Mean of 2 samples.

b. Dose calculated assuming ingestion exposure to contaminated surface soil on-site.

Exposure assumptions: inadvertent ingestion of 0.1 grams of soil/day, by Base personnel: 70 kg adult exposed 2 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

sediments at the site under investigation. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects which was calculated taking into account the calculated dose. The third column describes the target organs for potential effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

As shown in Table 5-6, the hazard index for lead does not exceed 1.0. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to lead in soils at Site 2 for Base personnel, or for children hypothetically exposed offsite. No potentially carcinogenic chemicals were detected in soils under evaluation.

5.7 CONCLUSIONS AND RECOMMENDATIONS

Soil-gas survey results showed that there was no discernible hydrocarbon contamination in the vicinity of the suspected burn pit area underneath the present Power Check Pad. Two sampling locations exhibited extremely low levels (PPT) of organic solvents in the soil-gas, which could be related to any number of small volume sources, could have been caused by ambient air conditions, and showed no trends of any significant contamination. Soil samples at the site showed no evidence of site-related contamination. Lead was found at a normal natural background level and is not related to any site activities. Groundwater sampling showed no evidence of site-related contamination. Only inorganic compounds, in concentrations in agreement with natural background levels, were detected. Because of the downgradient monitoring well located at this site, the soil-gas survey, and two soil borings drilled during a previous study at a different suspected burn pit location, Site 2 has been decently monitored. No soil or groundwater contamination is known to exist at either suspected location. The site is recommended for further study by a direct push sampling technique. It is anticipated that this action will lead to the drafting of a decision document to eliminate the site from further IRP study.

6.0 SITE 3 - FORMER FIRE TRAINING AREA #2

This section provides information specifically pertaining to Site 3. This includes past investigation activities, RI objectives and activities performed, the results and significance of RI findings, risk assessment results, and conclusions and recommendations. Background information of past activities is provided in Sections 6.1 and 6.2. A complete description of activities and results of IRP Phase II, Stage 1, Part 1 are presented in "Installation Restoration Program, Phase II-Confirmation/Quantification Stage 1, Buckley Air National Guard Base" (Dames & Moore 1986).

6.1 SITE DESCRIPTION AND PREVIOUS WORK

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley ANGB and to assess potential for contaminant presence and migration. This phase consisted primarily of interviews and record review.

The Base Fire Chief reports that FTA No. 2 was located and was used between 1950 and 1972. The site is reportedly unlined and undiked and is within 2000 ft of Base Well No. 4, a potable water-supply well. This well is normally inactive. Hazardous materials including AVGAS and JP-4 jet fuel and, possibly, waste solvents were burned. A protein-based foam (which consisted primarily of ox blood) was used to extinguish fires (Butler 1988). Exercises were conducted about six times monthly. A hangar for small aircraft has been constructed on or immediately adjacent to the location.

IRP Phase II, Stage 1, Part 1, Confirmation/Quantification (Site Inspection)

Field investigations were conducted at Site 3. Activities included drilling, sampling, and logging of two soil borings. Chemical analyses of soil samples was performed.

Chemical analyses of soils from this site (see Table 6-1) indicated that no contamination was present. Again, however, the analytical results for lead, in particular, were inconclusive due to matrix interferences.

The Site Inspection did not adequately determine background contaminant concentrations, or confirm the presence and extent of lead and other contaminants at the site. Information identified to complete data gaps included determining the precise location of the site, downgradient contaminant concentrations, the extent of contamination, and defining the hydrogeologic properties of the underlying strata. Recommendations for further investigation included installing one downgradient well at FTA No. 2 (Site 3).

TABLE 6-1. ANALYTICAL RESULTS FOR SITE 3—FORMER FIRE TRAINING AREA NO. 2

Parameter (Sample Depth-Feet)	Method	Unit	Detection Limit	SOIL SAMPLES			
				B-1 (0-1.5)	B-1 (5-6.5)	B-2 (0-15)	B-2 (5-6.5)
Lead	239.1 ^a	mg/kg	10	47	39	40	43
Phenolics	420.2 ^a	mg/kg	1	2	ND	3	ND
Total Organic Carbon	415.1 ^a	mg/kg	5	5700	1900	4200	1500
Total Organic Halocarbons	9020 ^b	mg/kg	5	ND	ND	ND	ND
Moisture Content	160.3 ^a	Percent	1	16	16	15	19

^a Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

^b Test Methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, Modified for use on 0.1. Corp. Model 610 TOX Analyzer. ND - indicates value less than detection limits. Source: Dames & Moore, 1986 and 1987. "Installation Restoration Program, Phase II—Confirmation/Quantification, Stage 1."

6.2 REMEDIAL INVESTIGATION ACTIVITIES

Remedial investigation activities were based upon findings of the Preliminary Assessment (Phase I Records Search) and two earlier investigations (Phase II Stage 1, Parts 1 and 2-Confirmation/Quantification). Objectives of the RI were to:

- Determine if contamination of the various environmental media at Site 3 is present
- Identify the source(s) and nature of any contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risk any contamination may pose to public health, thereby determining the need for remedial actions.

RI Part 1 activities performed at Site 3 - Former Fire Training Area No. 2, included:

- Conducting a soil-gas survey
- Drill, sample, and abandon one soil boring
- Drill, soil sample, and install four monitoring wells
- Sample groundwater at the three wells
- Aquifer test the three wells.

Locations of field activity for the RI Part 1 at Site 3 are shown in Figure 6-1. A listing of sampling parameters is presented in Table 6-2a.

RI Part 2 activities at Site 3 included:

- Drill, sample, and abandon four soil borings.

Locations of the new boreholes (F2B-7, 8, 9, and 10) for Site 3 are also shown in Figure 6-1. A listing of sampling parameters for the RI Part 2 is presented in Table 6-2b.

6.3 SITE HYDROGEOLOGY

The lithology at this site consisted of a surficial layer 3 to 5 ft thick of loess underlain by variably consolidated, sands, claystone, and shale of the Denver Formation (Figures 6-2 and 6-3).

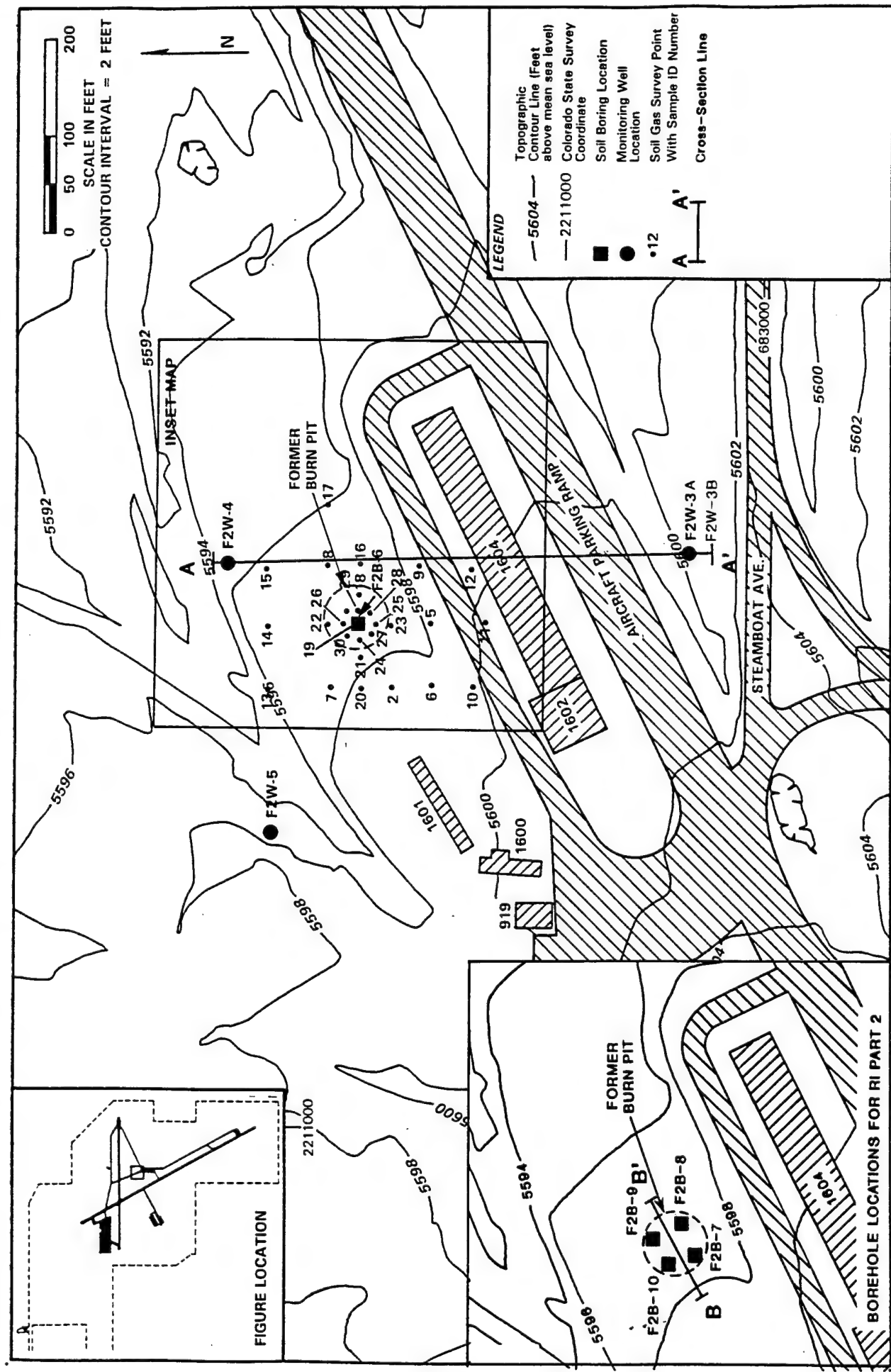


Figure 6-1 Field Activities for Site 3- Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado

TABLE 8-2a. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 3 - FORMER BASE FIRE TRAINING AREA NO. 2,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

SITE	SAMPLE ACTIVITY/I.D.	ACTIVITY LOCATION	MATRIX	CHEMICAL ANALYSES SAMPLES											GEOTECH (1) SAMPLES	
				% MOIST	VOC	BNA	HERB	PEST	ICP MET	LEAD ONLY	PHOS NIT	ANION CAT				
Soil Boring Boreholes																
F2B-6			Soil													
		In Former Burn Pit	Soil	4	4	1	-	-	-	1	-	1	-	-		
Monitoring Well Boreholes																
F2W-3		Upgradient	Soil	4	4	1	-	-	-	4	-	-	3			
F2W-4		Downgradient	Soil	4	4	-	-	-	-	4	-	-	-			
F2W-5		Downgradient	Soil	4	4	1	-	-	-	4	-	-	-			
Groundwater																
F2W-3A		Upgradient-Shallow	Water	-	1	1	-	-	-	1	-	1	-			
F2W-3B		Upgradient-Deep	Water	-	-	-	-	-	-	-	-	1	-			
F2W-4		Downgradient	Water	-	1	1	-	-	-	1	-	1	-			
F2W-5		Downgradient	Water	-	1	1	-	-	-	1	-	1	-			

(1) - Geotechnical analyses included test for Atterberg limits, grain-size analysis, and vertical permeabilities.

TABLE 6-2b. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 3 - FORMER BASE FIRE TRAINING AREA NO. 2,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 2

SITE	SAMPLE ACTIVITY/I.D	ACTIVITY LOCATION	MATRIX	CHEMICAL ANALYSES SAMPLES						
				VOC	SVOC	HERB	PEST/ PCBs	MET (1)	LEAD ONLY	ASBESTOS
Soil Boring Boreholes										
F2B-7		In Former Burn Pit	Soil	2	2	--	--	--	2	--
F2B-8		In Former Burn Pit	Soil	2	2	--	--	--	2	--
F2B-9		In Former Burn Pit	Soil	2	2	--	--	--	2	--
F2B-10		In Former Burn Pit	Soil	2	2	--	--	--	2	--

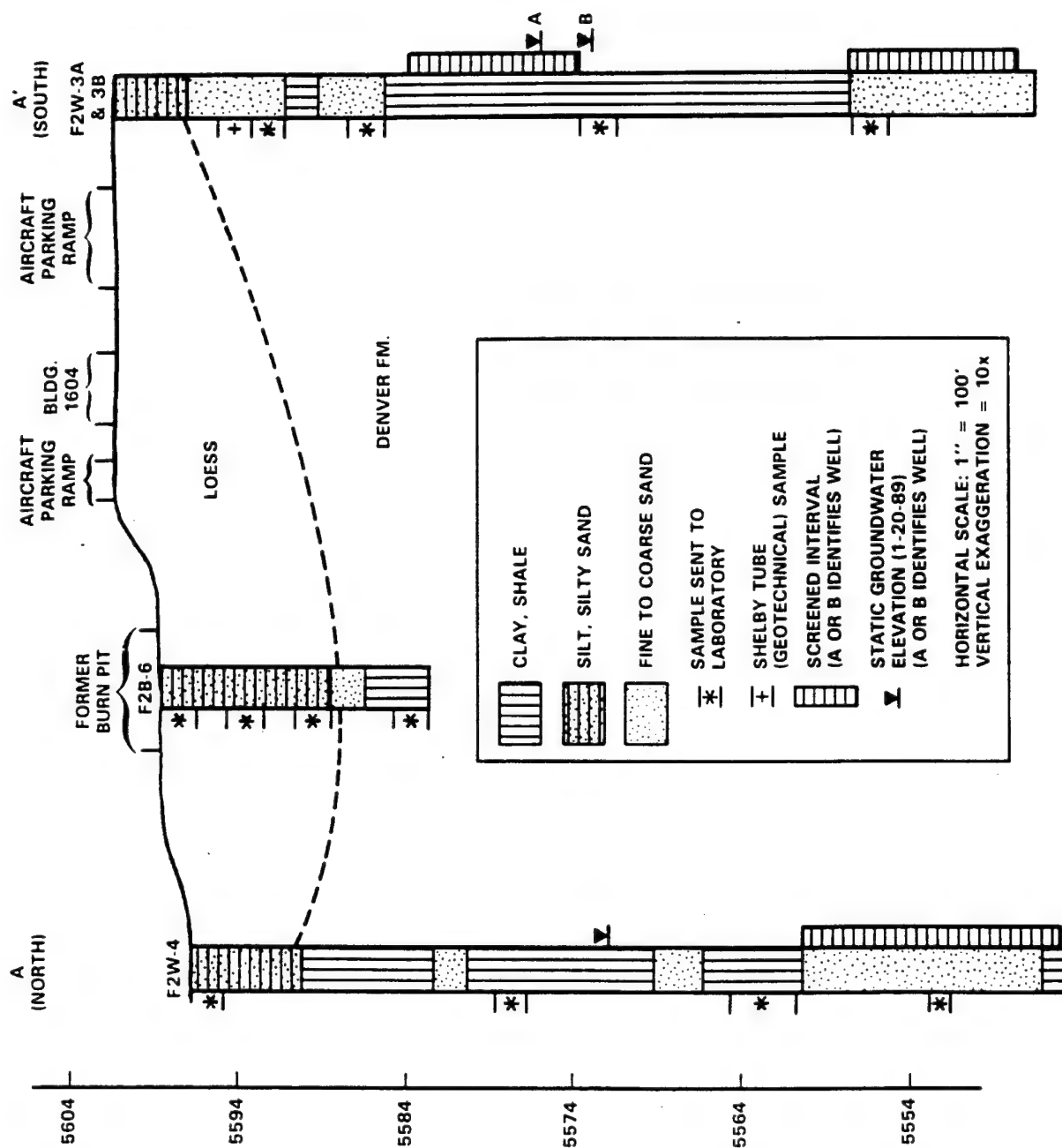


Figure 6-2 Generalized Geologic Profile of Site-3, Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado.

The predominant rock type was claystone which accounted for roughly 50% of the Denver Formation encountered during drilling.

Static water levels ranged from 24.8 to 28.2 ft BLS (1/20/89). The potentiometric surface map (Figure 6-4) shows that groundwater flow is northeasterly through the site with a hydraulic gradient of approximately 0.0015. This places wells F2W-4 and 5 generally downgradient of the site and locates the nested well pair F2W-3 A and B upgradient.

Slug testing conducted during the RI Part 1 yielded values of hydraulic conductivity from 4.6×10^{-4} ft/min to 6.2×10^{-5} ft/min. Using these values of hydraulic conductivity and hydraulic gradient results in a horizontal groundwater flow velocity of less than 2 ft/yr. This indicates that the monitoring wells may be too far downgradient to effectively monitor groundwater at the site.

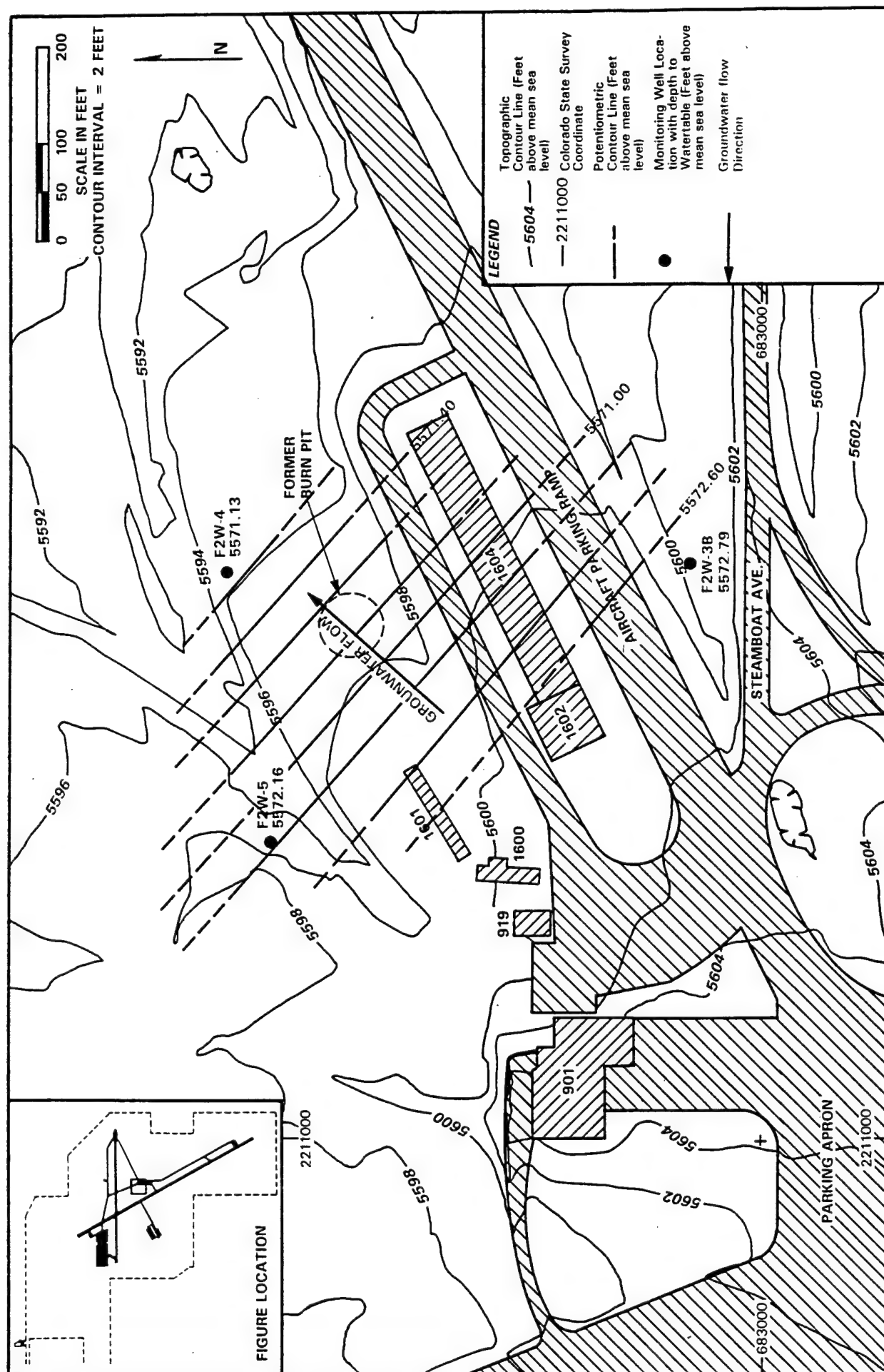
6.4 RESULTS AND SIGNIFICANCE OF FINDINGS

6.4.1 Soil-Gas Survey Results

Twenty-six samples were collected and analyzed during the RI Part 1 at Site 3, Fire Training Area 2. Samples were analyzed for volatile halocarbons and total hydrocarbons (inclusive of C¹ to C¹⁰ aliphatic and aromatic hydrocarbons). The location of soil-gas sampling points is shown in Figure 6-1. The samples were collected on grid spacings varying between 12.5 and 50 ft at 3 to 6 ft BLS. Details of the soil-gas procedures are discussed in Section 2.2.1, and the raw soil-gas data are included in Appendix F.

Halocarbon analysis showed one point (SG-19) with high concentrations of TCE and PCE (560 and 100 µg/l, respectively) compared to ambient background. Sampling points surrounding SG-19 show halocarbon concentrations decreasing two to four orders of magnitude within 25 ft, and no concentrations above sample detection limits were found at sampling points 50 ft from SG-19.

Total hydrocarbons were detected in 22 samples at concentrations from 0.1 to 100,000 µg/l, but concentrations decrease four to six orders of magnitude with increasing distance from SG-19. Figure 6-5 shows the total hydrocarbon results plotted next to the grid locations at Site 3. While most sampling points outside a 50-foot radius of SG-19 did not have total hydrocarbon concentrations above sample-detection limits, a few samples had detectable concentrations at levels that do not indicate extensive hydrocarbon contaminants exist in the soil horizon (0.8 to 3 µg/L). Benzene, toluene, and total xylenes were also detected at Site 3. Benzene was detected at 13 sampling locations above sample-detection limits in concentrations varying from 0.04 to 200,00 µg/l. Toluene and total xylenes were detected, but concentrations at most sampling locations were not quantified because of high sample detection limits. Therefore, no trends could be observed for toluene or total xylenes. These compounds are components of fuel, and at least benzene concentrations correlated well with the total hydrocarbon results.



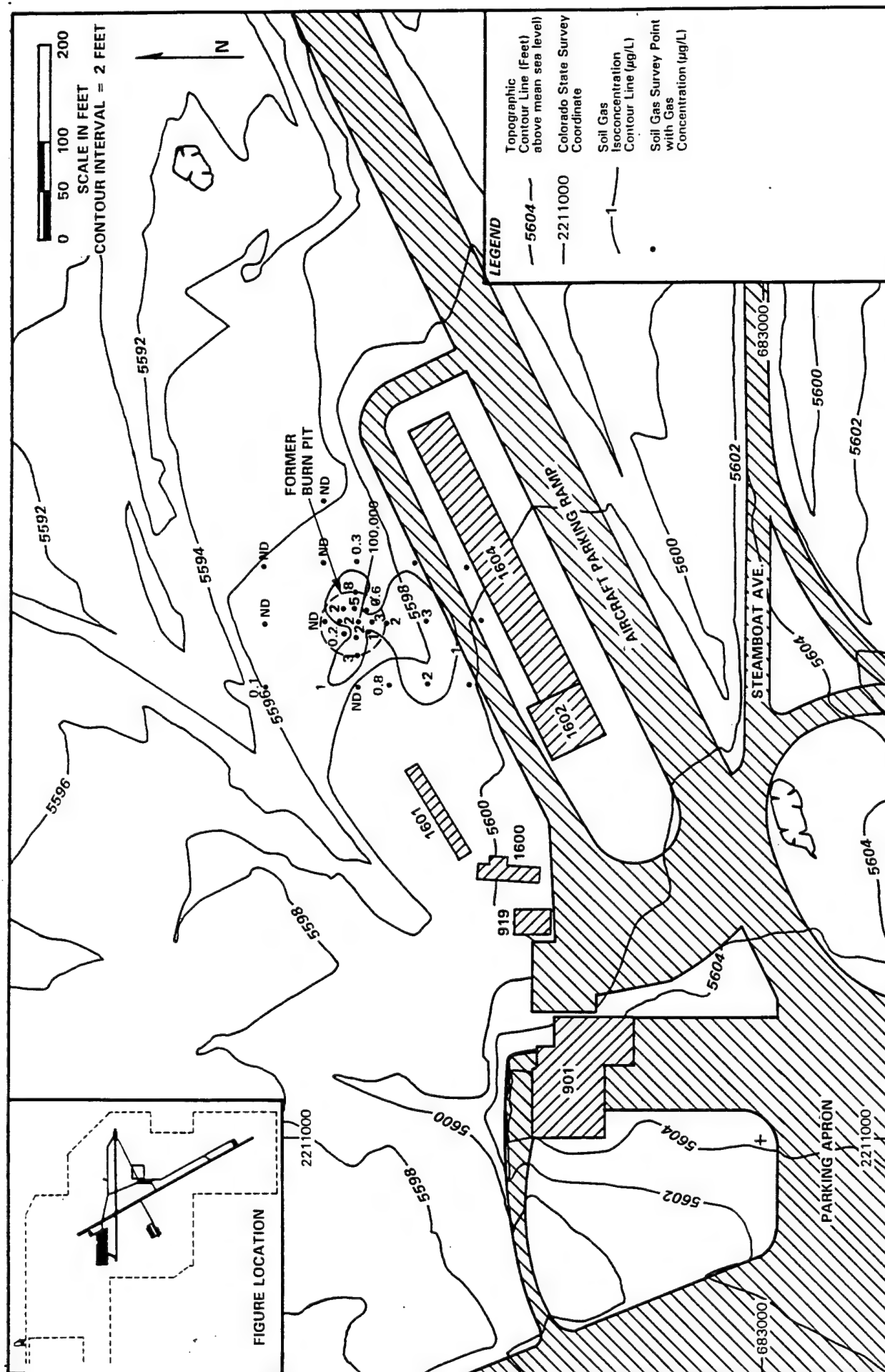


Figure 6-5 Soil Gas Isoconcentration Contour Map of Total Hydrocarbons for Site 3– Former Fire Training Area No. 2, Colorado Air National Guard, Buckley Field, Aurora, Colorado

The results from soil-gas surveying at Site 3 show a central area with high concentrations. The concentrations decrease several orders of magnitude towards the outside of a 25-ft radius circle. This circular area is most likely the location of the old burn pit. Low concentrations that were detected outside of the main circular area indicate the soil near the burn pit may have been spread around the site during abandonment.

6.4.2 Soil Boring Soil Sample Results

Soils from one soil boring (F2B-6) were sampled during the RI Part 1 at Site 3 with the objective of investigating possible soil contamination and migration of contaminants deeper into the alluvial and Denver Aquifers from the Former Fire Training Area No. 2. Soil samples were collected every 2 ft from the surface to 16 ft BLS. The soil boring was located near the area indicated as contaminated by soil-gas. Figure 6-1 shows the location of the soil boring.

The results from the soil boring samples analyzed during the RI Part 1 are summarized in Table 6-3a. Methylene chloride was detected in one sample, but it is considered to be present as a result of laboratory contamination (see Section 2.2.1). Toluene (30.6 µg/kg) and total xylenes (570 µg/kg) were detected in F2B-6 from 0 to 2 ft BLS. Several volatile organic compounds were detected in concentrations above the laboratory instrument linear range in the soil sample from 4 to 6 ft BLS (F2B-6): 1,1,2,2 tetrachloroethane (1056 µg/kg); trichloroethene (220 µg/kg); 1,1,2-trichloroethane (206 µg/kg); 2-hexanone (2020 µg/kg); toluene (324 µg/kg); and total xylenes (1940 µg/kg). No volatile organic compounds were detected in deeper soil samples from the soil boring. The sample from 0 to 2 ft BLS was the only sample analyzed for semivolatile organic compounds, and the results show 2-methylnaphthalene (21,300 µg/kg) detected at approximately three times the reporting limit. All of the detected volatile and semivolatile organic compounds are components of fuel which is used in fire training exercises. Lead was detected in all soil samples above the 95% CI of the background, but no detected concentrations were above the natural expected background range. Higher concentrations of lead did not correlate with higher concentrations of volatile and semivolatile organic compounds at this site. These data suggest that the volatile and semivolatile organic compounds and lead detected in the soil samples are not migrating deeper into the alluvium and entering the groundwater below the Former Fire Training Area No. 2.

During the RI Part 2, four 20-ft boreholes (F2B-7, 8, 9, and 10) were drilled within the burn area at Site 3. These additional soil borings were drilled to determine the vertical extent for possible future excavation. Soil samples were collected at 5-ft intervals and screened on-site by ECS with a Shimadzu 8A GC for toluene, ethylbenzene, xylene, methylene chloride, and TCE. In addition two samples per borehole were sent to NET Pacific for in-depth chemical analysis. Figure 6-1 also shows the locations (inset map) of the four additional soil borings drilled during the RI Part 2.

No trends in contaminant concentrations were observed from the on-site GC screening of soil boring samples. TCE (12 µg/kg) was detected in F2B-7 from 21.0 to 21.5 ft BLS. None of the five organic compounds screened on-site were detected in any of the other soil boring samples. The results for

TABLE 6-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 3 - FORMER FIRE
TRAINING AREA NO. 2, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

Sample #:F28-6(0-2) Sample #:F28-6(4-6) Sample #:F28-6(8-10)Sample #:F28-6(14-16)Sample #:F2W-3(8-10)Sample #:F2W-3(14-16)																					
Assoc. QA/QC		TB-4		Assoc. QA/QC		TB-4		Assoc. QA/QC		TB-4		Assoc. QA/QC		TB-10		Assoc. QA/QC		TB-10		Assoc. QA/QC	
FB-5		FB-5		FB-5		FB-5		FB-5		FB-5		FB-5		FB-10		FB-10		FB-10		FB-10	
LFW-8EQ		LFW-8EQ		LFW-8EQ		LFW-8EQ		LFW-8EQ		LFW-8EQ		LFW-8EQ		LFW-3EQ		LFW-3EQ		LFW-3EQ		LFW-3EQ	
ANALYTE	UNITS	ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS	
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)																					
Methylene Chloride	ug/Kg	12.13	B	5.74	ND	6.21	ND	6.25	ND	6.12	41.15	8	6.09	40.36	B	6.10					
Acetone	ug/Kg	ND		114.74	ND	124.16	ND	125.09	ND	122.32	ND		121.80	ND		121.91					
1,1,2,2-Tetrachloroethane	ug/Kg	ND		5.74	1055.62 *	6.21	ND	6.25	ND	6.12	ND		6.09	ND		6.10					
Trichloroethene	ug/Kg	ND		5.74	220.29 *	6.21	ND	6.25	ND	6.12	ND		6.09	ND		6.10					
1,1,2-Trichloroethane	ug/Kg	ND		5.74	205.74	6.21	ND	6.25	ND	6.12	ND		6.09	ND		6.10					
2-Hexanone	ug/Kg	ND		57.37	2015.57 *	62.08	ND	62.55	ND	61.16	ND		60.90	ND		60.95					
Toluene	ug/Kg	30.60		5.74	324.13 *	6.21	ND	6.25	ND	6.12	ND		6.09	ND		6.10					
Total Xylenes	ug/Kg	569.97		5.74	1944.87 *	6.21	ND	6.25	ND	6.12	ND		6.09	ND		6.10					
SEMI-VOLATILE ORGANICS (Method 8270)																					
2-Methylnaphthalene	ug/Kg	21270		7569	NA	NA	NA	NA	NA	NA	NA		NA	NA		NA					
INORGANICS																					
% MOISTURE	wt %	13		0.56	19	0.16	20	0.57	18	0.6	18		0.5	15		0.57					
LEAD	mg/Kg	20			14		12		18		18			13							

LEGEND

ND - Not Detected

NA - Not Analyzed

B - Compound was reported present in the laboratory method blank

* - Concentration is out of linear range

TABLE 6-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 3 - FORMER FIRE TRAINING AREA NO. 2, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1 (CONTINUED)

ANALYTE	UNITS	Sample #: F2U-3(28-30) Sample #: F2U-3(44-46) Sample #: F2U-4(0-2) Sample #: F2U-4(18-20) Sample #: F2U-4(34.5-36) Sample #: F2U-4(44-45)				Assoc. QA/QC				Assoc. QA/QC			
		ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)													
Methylene Chloride	ug/Kg	31.44 B		6.11	32.59 B	6.05	13.26	5.68	ND	6.07	ND	6.33	ND
Acetone	ug/Kg	ND	122.29	ND	ND	120.93	210.41	113.60	ND	121.33	ND	126.50	ND
1,1,2,2-Tetrachloroethane	ug/Kg	ND	6.11	ND	ND	6.05	ND	5.68	ND	6.07	ND	6.33	ND
Trichloroethene	ug/Kg	ND	6.11	ND	ND	6.05	ND	5.68	ND	6.07	ND	6.33	ND
1,1,2-Trichloroethane	ug/Kg	ND	6.11	ND	ND	6.05	ND	5.68	ND	6.07	ND	6.33	ND
2-Hexanone	ug/Kg	ND	61.15	ND	ND	60.47	ND	56.80	ND	60.66	ND	63.25	ND
Toluene	ug/Kg	ND	6.11	ND	ND	6.05	ND	5.68	ND	6.07	ND	6.33	ND
Total Xylenes	ug/Kg	ND	6.11	ND	ND	6.05	ND	5.68	ND	6.07	ND	6.33	ND
SEMI-VOLATILE ORGANICS (Method 8270)													
2-Methylnaphthalene	ug/Kg	NA			ND	401	NA		NA		NA		NA
INORGANICS													
% MOISTURE	wt %	18		0.6	5.2	0.5	12		18	0.59	21		18
LEAD	mg/Kg	13					15	0.57	15		17	0.63	5.9

LEGEND

ND- Not Detected

NA- Not Analyzed

B- Compound was reported present in the laboratory method blank

TABLE 6-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 3 - FORMER FIRE TRAINING AREA NO. 2, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1 (CONTINUED)

ANALYTE	UNITS	Sample #: F2W-5(4-6)				Sample #: F2W-5(4-6) DUP				Sample #: F2W-5(24-26)				Sample #: F2W-5(39-40)				Sample #: F2W-5(49-51)			
		ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING	ANALYSIS	REPORTING
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)																					
Methylene Chloride	ug/Kg	14.89	6.01	11.54	5.99	37.35	6.27	29.69	6.13	10.25	6.09										
Acetone	ug/Kg	ND	120.19	ND	119.72	ND	125.31	ND	122.50	ND	121.85										
1,1,2,2-Tetrachloroethane	ug/Kg	ND	6.01	ND	5.99	ND	6.27	ND	6.13	ND	6.09										
Trichloroethene	ug/Kg	ND	6.01	ND	5.99	ND	6.27	ND	6.13	ND	6.09										
1,1,2-Trichloroethane	ug/Kg	ND	6.01	ND	5.99	ND	6.27	ND	6.13	ND	6.09										
2-Hexanone	ug/Kg	ND	60.10	ND	59.86	ND	62.66	ND	61.25	ND	60.92										
Toluene	ug/Kg	ND	6.01	ND	5.99	ND	6.27	ND	6.13	ND	6.09										
Total Xylenes	ug/Kg	ND	6.01	ND	5.99	ND	6.27	ND	6.13	ND	6.09										
SEMI-VOLATILE ORGANICS (Method 8270)																					
2-Methylnaphthalene	ug/Kg	NA		NA		NA		ND	583	NA											
INORGANICS																					
% MOISTURE	wt %	17	0.59	16	0.59	20		18													
LEAD	mg/Kg	13		15		10	0.61	9.1	0.6	11	0.61										

LEGEND

ND - Not Detected

NA - Not Analyzed

B - Compound was reported present in the laboratory method blank

the borehole samples screened on-site are shown on cross-section B-B' (Figure 6-3). The on-site GC results are also presented in Appendix G-1.

All soil samples collected at Site 3 during the RI Part 2 were sent to the laboratory (NET Pacific) and analyzed for VOC's, SVOC's, and lead. The locations of the borehole soil samples sent to the laboratory are also shown on cross-section B-B' (Figure 6-3). The laboratory results are summarized in Table 6-3b.

The results from the laboratory analysis of borehole soil samples taken during the RI Part 2 at Site 3, show that the soils below the burn area have limited contamination. VOC results indicate the presence of methylene chloride in nine soil samples submitted to the laboratory for analysis. Methylene chloride was also detected in the associated equipment and laboratory method blanks. The presence of methylene chloride is considered related to outside contamination introduced during handling and/or analysis, and is not considered to be actual site contamination. In addition, none of the soil samples screened on-site had detections of methylene chloride. 2-butanone was detected in one soil sample F2B-8 (21.5 - 22.0) at a concentration of 22 µg/kg. However, the concentration is considered an estimated value. The mass spectral data indicate the presence of a compound that meets the identification criteria for 2-butanone, but the result is less than the sample quantitation limit and greater than zero. VOC TICs were detected in three soil samples submitted for analysis with concentrations of 49, 49, and 85 µg/kg.

Identifiable SVOCs were not detected in any of the Site 3 soil samples submitted to the laboratory with the exception of SVOC TICs. SVOC TICs were found in F2B-7 (1.5 - 2.0), F2B-8 (11.5 - 12.0), and F2B-9 (1.5 - 2.0). The total concentration of the SVOC TICs were 300, 6,840, and 2,590 µg/kg, respectively.

Lead concentrations for the nine soil samples sent the laboratory ranged from 12.7 to 24.7 mg/kg. The medium lead concentration (16.6 mg/kg) for these samples is slightly above the 95% CI of background (10 mg/kg) established at the base during the RI Part 1. However, the median concentration is within the expected background range (2.0 - 200 mg/kg) for lead in soil.

6.4.3 Monitoring Well Borehole Soil Sample Results

Soil samples were collected from three monitoring well boreholes installed during the RI Part 1 at Site 3. Figure 6-1 shows the locations of monitoring wells and Table 6-3a summarizes the data for monitoring well soil samples. Methylene chloride was detected in 10 well borehole soil samples, but it is considered a laboratory contaminant and is not indicative of environmental contamination (see Section 2.2.1). Acetone was detected in one soil sample (F2W-4) from 0 to 2 ft BLS, but because it was also detected in field QA/QC samples, it is not considered an environmental contaminant at this location. No other volatile or semivolatile organic compounds were detected above laboratory reporting limits in the soils from monitoring wells. Lead was detected in 8 of 12 monitoring well soil samples exceeding the 95% CI of the background, but the levels do not exceed the expected background range (Table 3-4). These data indicate that contaminants are not spreading laterally or

**Table 6-3B. Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 3 - Former Fire Training Area No. 2,
Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2**

SAIC ID Number	F2B-7(1.5-2.0)	F2B-7(1.5-2.0)RE	F2B-7(21.5-22.0)	F2B-8(11.0-11.5)	F2B-8(11.5-12.0)
Laboratory ID Number	12061	12061RE	12065	12066	12067
Collection Date	08/09/91	08/09/91	08/09/91	08/09/91	08/09/91
Associated Field QC Sample	F2-TBO4 LF-FB01,02	F2-TBO4 LF-FB01,02	F2-TBO4 LF-FB01,02	F2-TBO4 LF-FB01,02	F2-TBO4 LF-FB01,02
Parameter	LF-EB01,F2-EB02	LF-EB01,F2-EB02	LF-EB01,F2-EB02	LF-EB01,F2-EB02	LF-EB01,F2-EB02
Trace Metals (SOW 3/90)					
Lead	24.7 J(N)	NA	18.7 J(N)	14.6 J(N)	12.7 J(N)
Volatiles (SOW 3/90)					
Methylene Chloride	120 U(EB)	NA	77 U(EB)	97 U(EB)	110 U(EB)
2-Butanone	50 U	NA	50 U	50 U	50 U
TIC Total	0 (0)	NA	0 (0)	0 (0)	0 (0)
Semivolatiles (SOW 3/90)					
TIC Total	300 (2)	640 (4)	0 (0)	0 (0)	6840 (13)

U - compound/element was included in analysis, but was not detected

NA - not analyzed

TIC - tentatively identified compounds (number of non-TCL compounds detected)

J - estimated value

EB - compound also detected in the associated equipment blank

N - spike sample recovery outside control limits

**Table 6-3B. Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 3 - Former Fire Training Area No. 2,
Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2 (Continued)**

SAIC ID Number	F2B-8(21.5-22.0)	F2B-9(1.5-2.0)	F2B-9(21.5-22.0)	F2B-10(6.5-7.0)	F2B-10(21.5-22.0)
Laboratory ID Number	12068	12069	12070	12071	12072
Collection Date	08/09/91	08/09/91	08/09/91	08/09/91	08/09/91
Associated Field QC Sample	F2-TBO4 LF-FB01,02 LF-EB01,F2-EB02	F2-TBO4 LF-FB01,02 LF-EB01,F2-EB02	F2-TBO4 LF-FB01,02 LF-EB01,F2-EB02	F2-TBO4 LF-FB01,02 LF-EB01,F2-EB02	F2-TBO4 LF-FB01,02 LF-EB01,F2-EB02
Parameter					
Trace Metals (SOW 3/90)					
Lead	14.7 J(N)	14.8 J(N)	14.9 J(N)	16.8 J(N)	17.7 J(N)
Volatiles (SOW 3/90)					
Methylene Chloride	30 U(EB)	60 U(EB)	180 U(B)	190 U(MB)	110 U(MB)
2-Butanone	22 J	50 U	50 U	50 U	50 U
TIC Total	0 (0)	0 (0)	49 (1)	85 (1)	49 (1)
Semivolatile Organics (SOW 3/90)					
TIC Total	0 (0)	2590 (8)	0 (0)	0 (0)	0 (0)

U - compound/element was included in analysis, but was not detected
 B(org) - compound also detected in the associated laboratory method blank
 TIC - tentatively identified compounds (number of non-TCL compounds detected)
 J - estimated value
 EB - compound also detected in the associated equipment blank
 N - spike sample recovery outside control limits
 MB - compound also detected in the associated laboratory method blank

vertically throughout the soil horizon. Additional monitoring wells were not installed at Site 3 during the RI Part 2.

6.4.4 Groundwater Sample Results

During the RI Part 1 groundwater samples were collected and analyzed from four wells installed with screened intervals in the Denver Aquifer: F2W-3A; F2W-3B; F2W-4; and F2W-5. The objective of the groundwater sampling was to determine if the groundwater under Site 3 has been contaminated from the Former Fire Training Area No. 2. Additionally, wells F2W-3A and F2W-3B were installed as a cluster pair with the screened interval for F2W-3B being installed deeper in the Denver Aquifer under a clay layer. Analysis of groundwater from F2W-3B was intended solely to determine whether the clay layer was separating groundwater within the aquifer.

Table 6-4 summarizes the analytic results for groundwater at Site 3. Methylene chloride was the only volatile organic compound detected in groundwater samples from Site 3; however, methylene chloride is a common laboratory contaminant (see Appendix H) and is not indicative of contamination at this site. Bis(2-ethylhexyl)phthalate was detected in the groundwater sample from F2W-5; however, this compound was also detected in field QA/QC samples, and is not considered an environmental contaminant either at this site. No other volatile or semivolatile organic compounds were detected in the groundwater samples.

Lead was detected in one groundwater sample (F2W-3A), but at a concentration below the MCL established in the Safe Drinking Water Act. Major cations were analyzed in two samples (F2W-4 and F2W-5), and did not exceed State of Colorado drinking water standards (where specified). Calculated hardness is higher than background, but concentrations were comparable with other groundwater samples collected during the RI and were within concentration ranges expected in the Denver Aquifer near the Base (Hillier et al. 1983). Nitrate and sulfate concentrations exceeded State of Colorado standards (Colorado Department of Health 1971) in all wells at Site 3 and were above expected concentration ranges in this area (Hillier et al. 1983). Chloride concentrations exceeded State of Colorado standards in one well, but were below standard in all other groundwater samples from Site 3. High concentrations of nitrates is possibly due to the close proximity of two sewage leach fields at Site 3. High concentrations of cations and anions could also be due to the high amount of suspended solids in the samples. Comparisons of groundwater samples from F2W-3A and F2W-3B show no change in sulfate and phosphorus concentrations. Chloride concentrations decrease slightly at depth in F2W-3B. Nitrate concentrations decrease in F2W-3B, but nitrite concentrations increase substantially, indicating the samples from F2W-3B were collected from an anaerobic environment (which is expected from water deeper within an aquifer). In conclusion, the data do not indicate a difference between the groundwater from the two wells. Cation comparisons (calcium, magnesium, potassium, and sodium) from these two samples (F2W-3A and F2W-3B) show variations, but these differences are most likely caused by the high concentration of suspended solids in the samples.

TABLE 6-4. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN GROUNDWATER AT SITE 3 - FORMER FIRE TRAINING AREA NO. 2, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE	Sample #:F2U-3A		Sample #:F2U-3B		Sample #:F2U-4		Sample #:F2U-4DUP		Sample #:F2U-5	
	Assoc. QA/QC	TB-16 FB-20 F2U-5EQ(GW)	Assoc. QA/QC	TB-16 FB-20 F2U-5EQ(GW)	Assoc. QA/QC	TB-16 FB-20 F2U-5EQ(GW)	Assoc. QA/QC	TB-16 FB-20 F2U-5EQ(GW)	Assoc. QA/QC	TB-16 FB-20 F2U-5EQ(GW)
UNITS	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT

FIELD ANALYSIS										
pH	units	6.97	NA	NA	NA	NA	NA	NA	NA	NA
Temperature	deg. C	12	NA	12.0	12.0	12.0	12.0	12.0	12	12
Conductivity	umhos/cm	5740	NA	3700	3700	3700	3700	3700	4530	4530

VOLATILE ORGANICS (Method 8240)										
Methylene Chloride	ug/L	ND	5.00	NA	NA	ND	5.00	7.25	5.00	6.16

SEMI-VOLATILE ORGANICS (Method 8270)										
bis(2-ethylhexyl)phthalate	ug/L	ND	10	NA	NA	ND	10	ND	10	46

INORGANICS										

CALCIUM	ug/L	460000	50	380000	50	220000	50	220000	50	400000
CHLORIDE	mg/L	292	0.1	177	0.1	171	0.1	160	0.1	150
LEAD	ug/L	16	5	NA	NA	ND	5	ND	5	ND
MAGNESIUM	ug/L	160000	200	83000	200	48000	200	47000	200	82000
NITRATE	mg/L	207/205	0.01	119	0.01	31.1	0.01	31.9	0.01	173
NITRITE	mg/L	0.08	0.01	0.41/0.39	0.01	0.01	0.01	0.01	0.01	0.01
PHOSPHOROUS	mg/L	0.28	0.03	0.22	0.03	0.08	0.03	0.07	0.03	0.18
POTASSIUM	ug/L	9800	19	8800	19	11000	19	11000	19	9400
SODIUM	mg/L	1300000	900	820000	900	560000	900	560000	900	600000
SULFATE	mg/L	2280	0.2	2290	0.2	1420	0.2	1290	0.2	1840

LEGEND

ND - Not Detected

NA- Not Analyzed

Specific conductivity was measured for each groundwater sample except the sample from F2W-3B. The specific conductivity varies between 3700 and 5740 $\mu\text{homs/cm}$, which is comparable with other wells at the Base. No trend was observed, and measured specific conductivity variations may be affected, in part, by dissolution of suspended solids in the samples. The pH was neutral (6.97) in samples from L2W-3A. No other pH measurements were obtained at Site 3; therefore, no trend could be determined.

Previously installed monitoring wells at Site 3 were not sampled during the RI Part 2.

6.5 SUMMARY OF FINDINGS

The soil-gas survey detected elevated (relative to background) concentrations of total hydrocarbons, benzene, toluene, and total xylenes in a small semicircular area with radius of approximately 25 ft. Lower concentrations were detected in an irregular pattern up to 50 ft from the semicircular area. This pattern is most likely due to regrading and spreading of the soils surrounding the fire pit during abandonment.

Volatile organic compounds were detected in one soil boring (F2B-6) above 10 ft BLS. Deeper soils from this boring and soils collected during monitoring and well drilling indicate that contaminants are not migrating deeper into the soil. 2-butanone was detected in one soil boring (F3B-8) 21.5 ft BLS, however it was an estimated value less than the sample quantitation limit. Lead was detected above the 95% confidence interval of local background samples in most soils, but did not exceed expected background ranges for soils.

Selenium and sulfate were detected above background sample levels in all wells, but were within expected ranges for groundwater in the Denver Aquifer surrounding the Base (Hillier et al. 1983). Nitrates were above the MCLs and expected ranges, but these higher concentrations are most likely caused by the close proximity of two sewer leach fields.

6.6 RISK ASSESSMENT RESULTS

6.6.1 Groundwater Risks

In order to examine the magnitude of this contamination a summary table, Table 6-5, has been prepared showing mean and maximum levels of inorganic toxicants in groundwater at Site 3. Since no detectable quantities of organic substances were detected, there are no ARAR tables for that type of contaminant. For comparison, the applicable or relevant and appropriate requirements (ARARs; i.e., federal and state water-quality criteria and standards) are included. As specified in the Superfund Amendments and Reauthorization Act of 1986 (SARA), on-site remedial actions are required to attain ARARs unless such requirements are formally waived.

Referring to Table 6-5, it can be observed that the reported levels of nitrate and sulfate exceed ARAR levels or TBC guidelines. The TBC guideline for sulfate is an SMCL that is not enforceable and is

TABLE 6-5. ARARs FOR INORGANIC CHEMICALS FROM SITE 3 GROUNDWATER AT THE BUCKLEY ANGB
REMEDIAL INVESTIGATION: PART 1

Inorganic Constituent	Mean Concentration (ug/L)	Maximum Concentration (ug/L)	(a)		(b)	(c)		(g)		
			Drinking Water MCL (ug/L)	Drinking Water MCLG (ug/L)		Adjusted for Drinking Water Only (ug/L)	Colorado Drinking Water Standards (ug/L)	One-Day 10 kg (ug/L)	Ten-Day 10 kg (ug/L)	Longer-Term 70 kg (ug/L)
Calcium	336,000	460,000								
Chloride	190,000	292,000								
Lead	5.2	16	50	20 ^(d)	50		50			
Magnesium	84,000	160,000								
Nitrate	112,000	207,000	10,000	10,000 ^(d)	10,000 ^(d)		10,000	111,000	111,000	111,000
Nitrite	100	410			1,000					
Phosphorous	170	280								
Potassium	10,000	11,000								
Sodium	534,000,000	820,000,000								
Sulfate	1,824,000	2,290,000	250,000 ^(e)							

(a) Maximum Contaminant Levels established under the Safe Drinking Water Act.

(b) Maximum Contaminant Level Goal established under the Safe Drinking Water Act.

(c) Ambient Water Quality Criteria established under the Clean Water Act, adjusted for drinking water.

(d) Proposed MCL or MCLG.

(e) Secondary Maximum Contaminant Level (SMCL) established under the Safe Drinking Water Act - not an ARAR.

(f) Criterion established based on taste and odor effects (organoleptic) not human health effects.

(g) Federal Drinking Water Health Advisories are not ARARs, but values to be considered (TBC) in evaluating the significance of observed levels of contamination in drinking water supplies.

(h) Drinking Water Health Advisory for a 10 kg child.

(i) Drinking Water Health Advisory for a 70 kg adult.

(j) Mean concentration of groundwater from Site 3. Mean values were calculated treating "not detected" results as if the subject chemical was present at half the detection limit.

levels detected in wells at this site are probably associated with their location relative to nearby septic tank leach fields. The reported concentrations for lead and nitrite are below ARAR levels or TBC guidelines. There are no ARARs for calcium, chloride, magnesium, phosphorous, potassium, and sodium. Since all detected quantities of organic and inorganic compounds are below ARAR levels or TBC guidelines, or there is a reasonable explanation (not related to hazardous material disposal or handling practices) for the occurrence of elevated levels - a risk characterization was not conducted for the groundwater-consumption pathway.

6.6.2 Soil Exposure Risks

Table 6-6 presents the results of the risk assessment for Site 3 soils. The table first provides a summary of mean levels of chemical contaminants observed in soils from RI Parts 1 and 2. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects, which were calculated taking into account the calculated dose. The third column describes the target organs for potential effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

As shown in Table 6-6, none of the hazard indices for any subject chemical exceed 1.0. In addition, the hazard indices for combined exposure across chemicals is also less than 1.0. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to compounds in soils from Site 3 for Base personnel, or for children hypothetically exposed offsite. None of the carcinogenic risk estimates exceed 10^{-6} indicating that there is no risk from potential carcinogens at the site.

6.7 CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the RI data collected at Site 3 did not confirm the absence of VOC contamination from the SI. Soil-gas survey results revealed the presence of an approximately 50-ft diameter area of principally hydrocarbon contamination centered within the abandoned burn pit location. Volatile compounds measured in the soil-gas contamination consisted of benzene, toluene, and xylenes, which are components of the fuel burned in the pit. One soil-gas sample taken in the middle of the pit contained elevated levels of chlorinated organic solvents (TCE and PCE) reportedly associated with waste fuels burned in the pit. The area of soil hydrocarbon contamination was vertically defined by drilling (RI Parts 1 and 2) five soil borings through the former burn pit. Contamination consistent

Table 6-6. Risk Characterization for Site 3: Soil Exposure

Compound	Mean Levels in Soil (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic				
Beryllium				
Cadmium				
Chromium				
Copper				
Lead	14.00	2.30E-03	CNS, Kidney	
Mercury				
Nickel				
Phosphorous				
Selenium				
Silver				
Thallium				
Zinc				
ORGANICS				
Acenaphthalene				
Anthracene				
Ethylbenzene				
Fluorene				
2-Hexanone	0.10	Data inadequate for risk assessment (HEAST 1991)		
Methylene Chloride				
2-Butanone	0.048	2.20E-07	Fetotoxicity	
2-Methylnaphthalene	1.82	Data inadequate for risk assessment		
Naphthalene				
Nitrobenzene				
N-Nitrobenzene				
Phenathrene				
1,1,2,2-Tetrachloroethane	0.05			9.8E-10
Tetrachloroethylene				
Toluene	0.02	1.53E-08	CNS	
1,1,1-Trichloroethane				
1,1,2-Trichloroethane	0.014			7.0E-11
Trichloroethylene	0.015			1.6E-11
Xylenes	0.10	1.1E-09	CNS	
Hazard Index: Combined Exposure		2.3E-03		
Excess Lifetime Cancer Risk: Combined Exposure				1.1E-09

- a. Mean of 5 samples. Mean concentrations were determined treating "not detected" results as if the chemical was present at half the detection limit.
- b. Dose calculated assuming ingestion exposure to contaminated surface soil on-site.
Exposure assumptions: inadvertent ingestion of 0.1 gram of soil/day, by Base personnel: 70 kg adult exposed 2 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

with waste fuel (both volatile and semivolatile) was found to a depth of 6 ft in soil boring F2B-6. Samples below the 6-ft depth within this boring, as well as samples collected from the other four boreholes drilled within the former burn pit show no evidence of any site-related contamination. Levels of several inorganic compounds were detected in these samples but are consistent with natural background levels. No site-related groundwater contamination was found in the monitoring wells installed at this site. Several inorganic compounds were detected in these groundwater samples, but the levels are consistent with natural background levels.

The results of the soil boring F2B-6 (taken through the center of the burn pit) clearly show that soil contamination is limited to 8 ft or less in depth, well above the 25-ft depth of the potentiometric water surface. Furthermore, low permeability clay layers exist above the groundwater, creating confined aquifer conditions beneath the site and also protecting groundwater from the surficial contamination. Because of these clay layers, groundwater contamination is unlikely; therefore, this site has been adequately monitored to detect the extent of contamination and affected media. A baseline public health evaluation indicates that there is no significant carcinogenic or noncarcinogenic risk associated with the limited soil contamination at the site. Therefore, no immediate action is necessary at this site. If the Relative Risk Program of the DOD supports funding, a groundwater monitoring well should be installed to provide data for a decision document supporting the elimination of the site from further IRP study.

7.0 SITE 4 - FIRE TRAINING AREA #3

This section provides information specifically pertaining to Site 4. This includes past investigation activities, RI objectives and activities performed, the results and significance of RI findings, risk assessment results, and conclusions and recommendations. Background information of past activities is provided in Sections 7.1 and 7.2. A complete description of activities and results of IRP Phase II, Stage 1, Part 1 are presented in "Installation Restoration Program, Phase II-Confirmation/Quantification Stage 1, Buckley Air National Guard Base" (Dames & Moore 1986).

7.1 SITE DESCRIPTION AND PREVIOUS WORK

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley ANGB and to assess potential for contaminant presence and migration. This phase consisted primarily of interviews and record review.

FTA No. 3 is located west of Building 801; it has been in operation since 1972. Current fire-training procedures are to saturate the surface with water to reduce infiltration, ignite approximately 150 gal of water-contaminated JP-4 jet fuel spread on the pad, and extinguish the fire with water and 6% (currently 3%) aqueous film-forming foam (AFFF). Twenty-four exercises are conducted annually using about 400 gal of AFFF. Approximately 50 to 70% of the fuel is burned (Simons, Li, & Associates, Inc. 1982; Butler 1988).

IRP Phase II, Stage 1, Part 1, Confirmation/Quantification (Site Inspection)

Field investigations were conducted at Site 4. Activities included drilling, sampling, and logging of two soil borings. Chemical analyses of soil samples was performed.

Chemical analyses of soils from this site (see Table 7-1) indicated that contamination was present as measured by total organic halogens (TOX; up to 8.6 mg/kg) and phenolics (up to 6 mg/kg). As at previous sites, lead data for soils were inconclusive as to actual levels due to matrix effects associated with the test procedure. The Site Inspection did not determine background contaminant concentrations, or confirm the presence and extent of lead or other contaminants at this site. Information identified to complete data gaps have included determining the precise location of the site, downgradient contaminant concentrations, the extent of contamination, and defining the hydrogeologic properties of the underlying strata. Recommendations for further investigation included installing three new wells at Fire Training Area No. 3 (Site 4).

7.2 REMEDIAL INVESTIGATION ACTIVITIES

Remedial investigation activities were based upon findings of the Preliminary Assessment (Phase I Records Search) and two earlier investigations (Phase II Stage 1, Parts 1 and 2-Confirmation/Quantification). Objectives of the RI were to:

TABLE 7-1. ANALYTICAL RESULTS FOR SITE 4 -- FORMER FIRE TRAINING AREA NO. 3

Parameter (Sample Depth-Feet)	Method	Unit	Detection Limit	SOIL SAMPLES			
				B-1 (0-1.5)	B-1 (5-6.5)	B-2 (0-15)	B-2 (5-6.5)
Lead	239.1 ^a	mg/kg	10	20	37	45	29
Phenolics	420.2 ^a	mg/kg	1	6	5	4	3
Total Organic Carbon	415.1 ^a	mg/kg	5	5800	4300	3700	1500
Total Organic Halocarbons	9020 ^b	mg/kg	5	8.6	ND	ND	ND
Moisture Content	160.3 ^a	Percent	1	11	11	9	4

^a Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

^b Test Methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, Modified for use on 0.1. Corp. Model 610 TOX Analyzer. ND - indicates value less than detection limits. Source: Dames & Moore, 1986 and 1987. "Installation Restoration Program, Phase II—Confirmation/Quantification, Stage 1."

- Determine if contamination of the various environmental media at Site 4 is present
- Identify the source(s) and nature of any contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risk any present contamination may pose to public health, thereby determining the need for remedial actions.

RI Part 1 activities performed at Site 4 - Fire Training Area No. 3, included:

- Conducting a soil-gas survey,
- Drill, sample, and abandon two soil borings
- Drill, soil sample, and install three monitoring wells
- Sample groundwater at the three wells
- Aquifer test the three wells.

Locations of field activity for the RI Part 1 at Site 4 are shown in Figure 7-1. A listing of sampling parameters is presented in Table 7-2a.

RI Part 2 activities performed at Site 4 included:

- Drill, sample, and abandon five soil borings
- Drill, soil sample, and install three monitoring wells
- Sample groundwater at the three new wells and three previously installed wells.

Locations of the new boreholes (F3B-9, 11, 12, 14, and 15) and monitoring wells (F3W-8, 10, and 13) for Site 4 are also shown in Figure 7-1. A listing of sampling parameters for the RI Part 2 is presented in Table 7-2b.

7.3 SITE HYDROGEOLOGY

The deposits encountered during drilling at this site were the coarsest of any found on base. Underneath a thin 3-ft layer of loess were greater than 45 ft of sand, gravel, and some silt (Figures 7-2, 7-3, 7-4 and 7-5). These deposits, which comprised the thickest continuous bed of

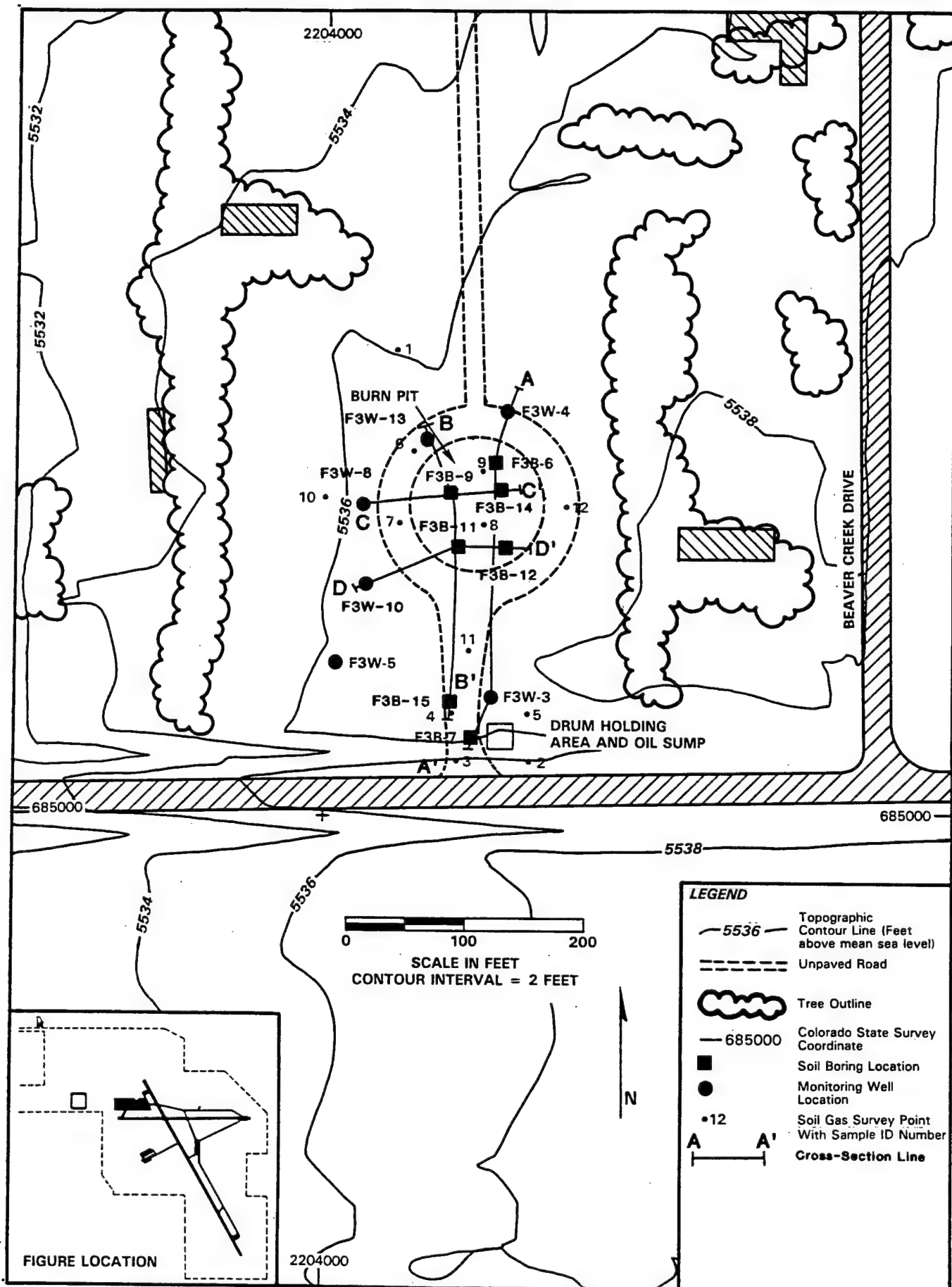


Figure 7-1 Field Activities for Site 4-Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado

TABLE 7-2a. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 4 - BASE FIRE TRAINING AREA NO. 3,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

SITE	SAMPLE ACTIVITY/I.D.	ACTIVITY LOCATION	MATRIX	CHEMICAL ANALYSES SAMPLES											GEOTECH (1) SAMPLES	
				% MOIST	VOC	BNA	HERB	PEST	ICP MET	LEAD ONLY	PHOS NIT	ANION CAT				
Soil Boring Boreholes																
	F38-6	In Burn Pit	Soil	4	4	1	-	-	-	4	-	-	-	-	-	-
	F38-7	Adj. to Fuel Storage	Soil	4	4	1	-	-	-	4	-	-	-	-	-	-
Monitoring Well Boreholes																
	F3W-3	Upgradient	Soil	4	4	2	-	-	-	4	-	-	-	3	-	-
	F3W-4	Downgradient	Soil	4	4	1	-	-	-	4	-	-	-	-	-	-
	F3W-5	Downgradient	Soil	4	4	1	-	-	-	4	-	-	-	-	-	-
Groundwater																
	F3W-3	Upgradient	Water	-	1	1	-	-	-	1	-	1	-	-	-	-
	F3W-4	Down/Cross-gradient	Water	-	1	1	-	-	-	1	-	1	-	-	-	-
	F3W-5	Cross-gradient	Water	-	1	1	-	-	-	1	-	1	-	-	-	-

(1) - Geotechnical analyses included test for Atterberg limits, grain-size analysis, and vertical permeabilities.

TABLE 7-2b. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 4 - BASE FIRE TRAINING AREA NO. 3,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 2

SITE	SAMPLE ACTIVITY/I.D	ACTIVITY LOCATION	MATRIX	CHEMICAL ANALYSES SAMPLES						
				VOC	SVOC	HERB	PEST/ PCBs	MET (1)	LEAD ONLY	ASBESTOS
Soil Boring Boreholes										
F3B-9		In Former Burn Pit	Soil	2	2	--	--	--	5	--
F3B-11		In Former Burn Pit	Soil	2	2	--	--	--	4	--
F3B-12		In Former Burn Pit	Soil	2	2	--	--	--	3	--
F3B-14		In Former Burn Pit	Soil	2	2	--	--	--	3	--
F3B-15		Adj. to Fuel Storage	Soil	2	2	--	--	--	2	--
Groundwater										
F3W-3		Upgradient	Water	1	1	--	--	--	1	--
F3W-4		Down/Cross-gradient	Water	1	1	--	--	--	1	--
F3W-5		Cross-gradient	Water	1	1	--	--	--	1	--
F3W-8		Downgradient	Water	1	1	--	--	--	1	--
F3W-10		Downgradient	Water	1	1	--	--	--	1	--
F3W-13		Downgradient	Water	1	1	--	--	--	1	--

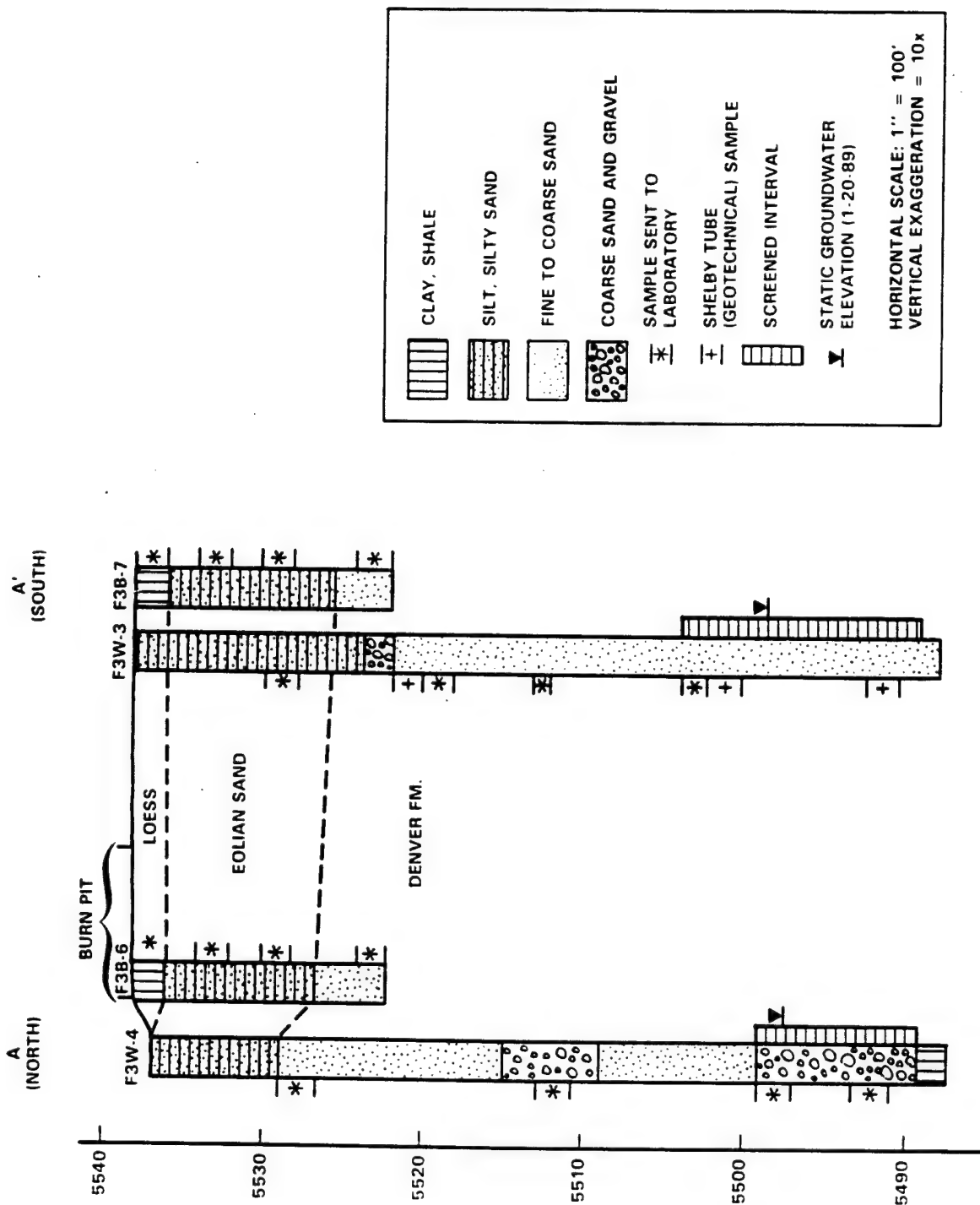


Figure 7-2 Generalized Geologic Profile A-A' of Site-4, Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado.



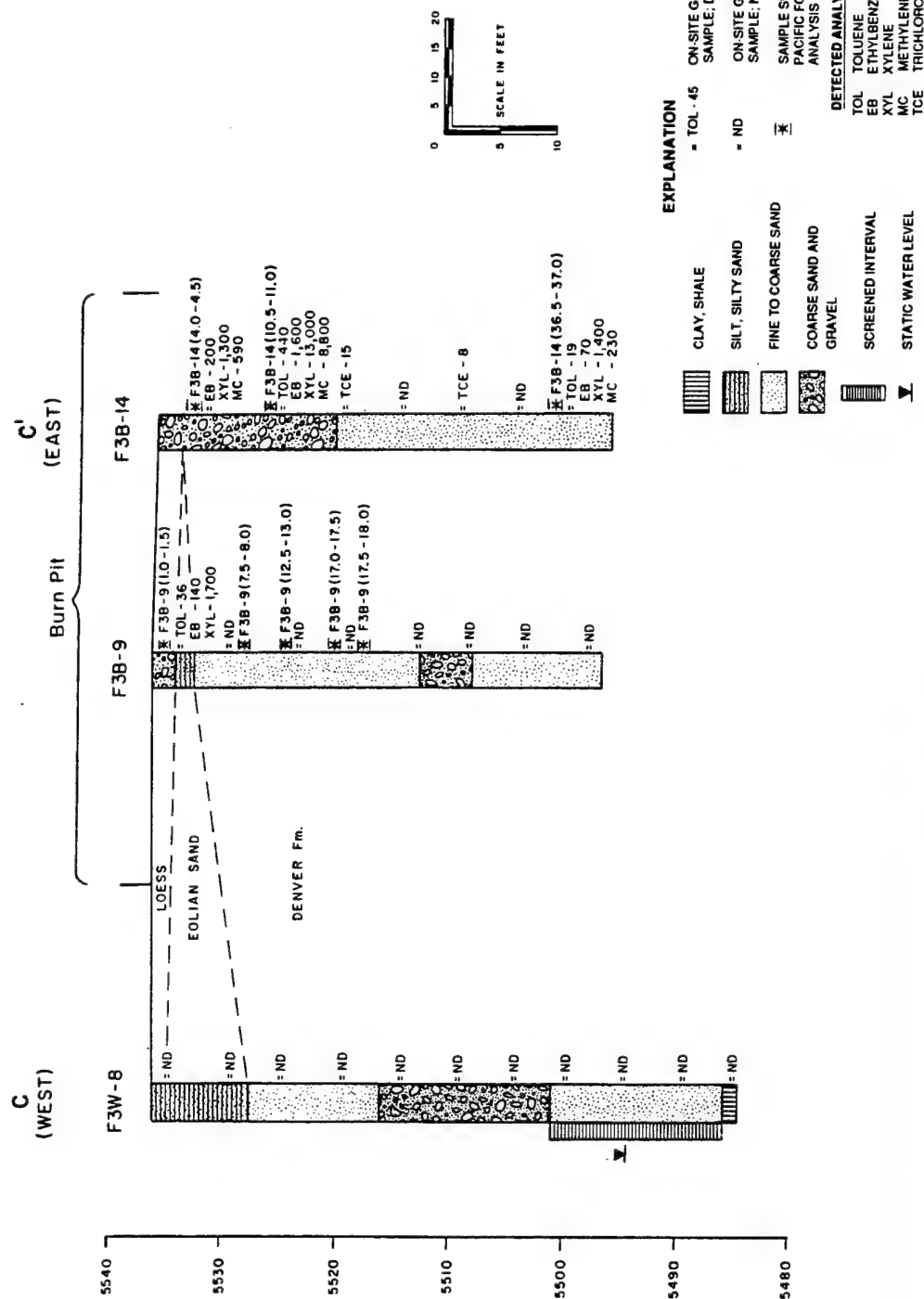


FIGURE 7-4 Generalized Geologic Profile C-C' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil ($\mu\text{g/kg}$) at Site 4, Fire Training Area No. 3, Colorado Air National Guard, Aurora, Colorado.

SAIC

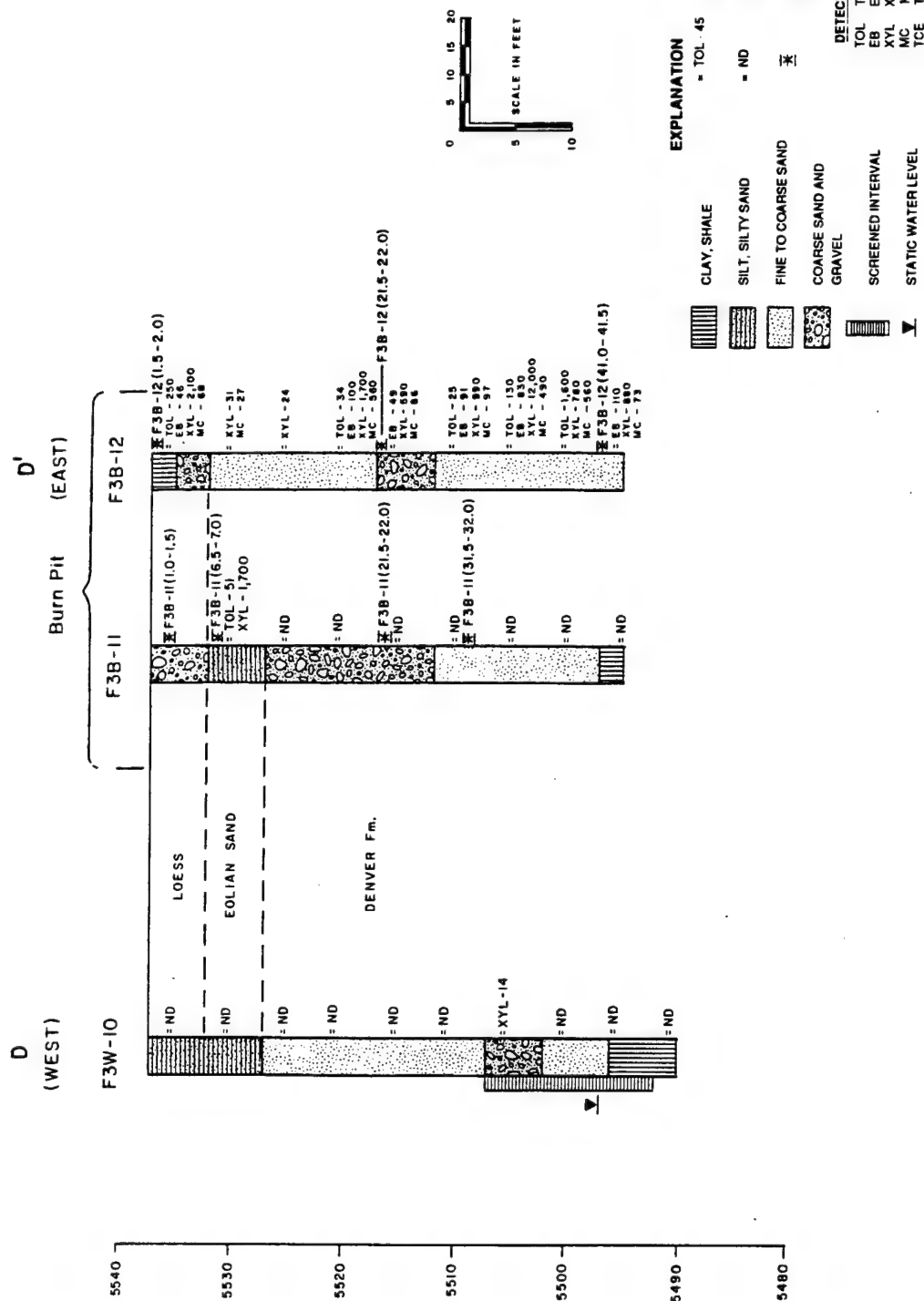


FIGURE 7-5 Generalized Geologic Profile D-D' Showing Vertical Distribution of On-Site Screening Results in Subsurface Soil (µg/kg) at Site 4, Fire Training Area No. 3, Colorado Air National Guard, Aurora, Colorado.

SAIC

coarse-grained sediment encountered at the Base, were both eolian deposits and Denver Formation deposits; however, the contact between these deposits cannot be discerned.

Static water levels at the site ranged from 38.4 to 39.2 ft BLS (1/20/89) and from 39.9 to 40.7 ft BLS (8/15/91). The potentiometric surface maps (Figures 7-6 and 7-7) show that the flow is to the northwest with a hydraulic gradient of approximately 0.0096. This flow direction was unexpected because the potentiometric surface generally mimics topography. The flow direction was originally expected to be to the southwest because of a strong southwestern topographic slope just south of the site. These groundwater-flow patterns indicate that wells F3W-8, 10 and 13 are downgradient; F3W-4 and 5 are cross-gradient and F3W-3 upgradient of the burn pit (source area).

Slug testing conducted during the RI Part 1 yielded values of hydraulic conductivity ranging from 2.4×10^{-1} to 4.5×10^{-2} ft/min. All tests and logs indicate that the aquifer in this area is under unconfined conditions.

7.4 RESULTS AND SIGNIFICANCE OF FINDINGS

7.4.1 Soil-Gas Survey Results

Twelve soil-gas samples were collected and analyzed during the RI Part 1 at Site 4, Fire Training Area 3. Samples were analyzed for volatile halocarbons and total hydrocarbons (inclusive of C^1 to C^{10} aliphatic and aromatic hydrocarbons). The locations of soil-gas sampling points are shown in Figure 7-1. The samples were collected on irregular grid spacings varying between 50 and 100 ft at 6 ft BLS. Details of the soil-gas procedures are discussed in Section 2.2.1, and the raw soil-gas data are included in Appendix F.

Halocarbon analysis showed low concentrations of PCE, TCE, and 1,1,1 TCA at several sampling locations. PCE was the analyte found in the most sampling locations ranging in concentrations from 0.006 to 0.8 $\mu\text{g/l}$. The samples with the highest PCE concentrations were located near the oil sump and within the approximate burn pit perimeter.

Four sampling locations at Site 4 showed elevated total hydrocarbon concentrations (167 to 320,000 $\mu\text{g/l}$). Figure 7-8 shows a contour plot of concentrations of total hydrocarbons around Site 4. The plot shows an area of potential soil contamination, measuring approximately 170 by 260 ft, located directly under and adjacent to the burn pit perimeter. Benzene was also detected at five sampling locations, ranging in concentration from 4 to 70,000 $\mu\text{g/l}$. Benzene is a component of fuel, and it correlated well with the total hydrocarbon results. Toluene and total xylenes were detected, but concentrations were not quantified because of high sample detection limits.

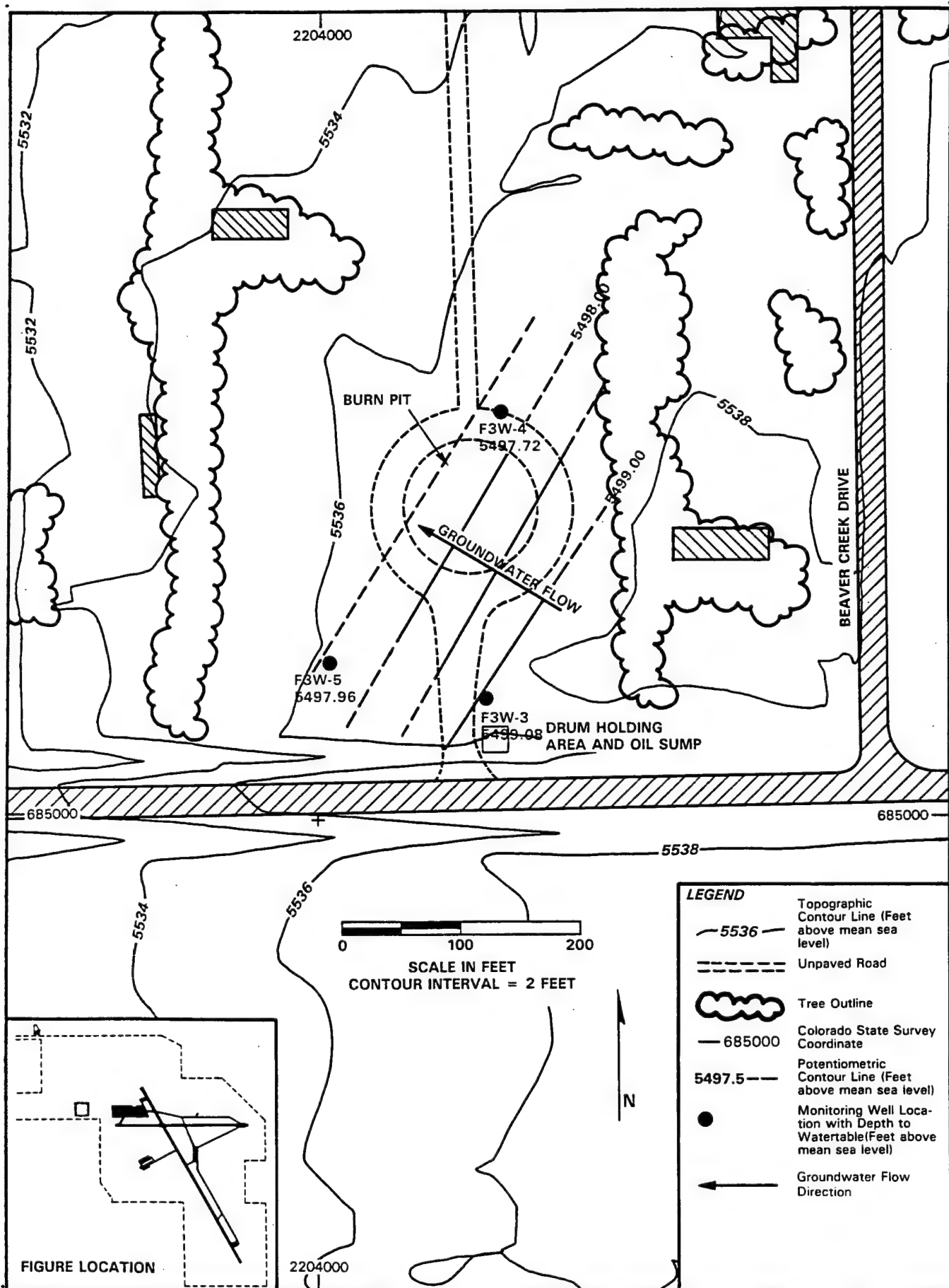


Figure 7-6 Potentiometric Surface Contour Map of Site-4, Fire Training Area No. 3, January 19, 1989, Colorado Air National Guard, Buckley Field, Aurora, Colorado

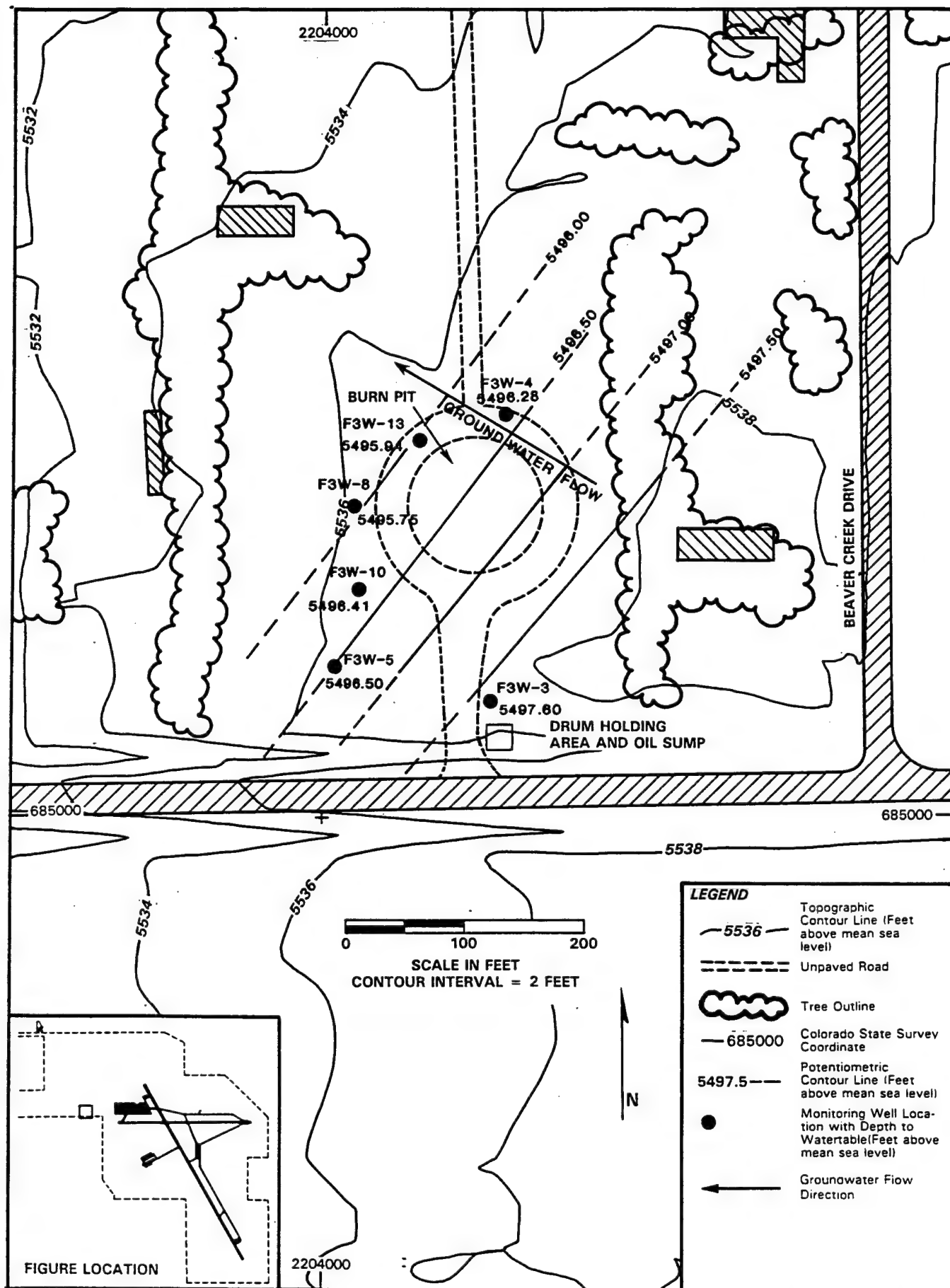


Figure 7-7. Potentiometric Surface Contour Map of Site 4-Fire Training Area No. 3, August 15, 1991, Colorado Air National Guard, Buckley Field, Aurora, Co

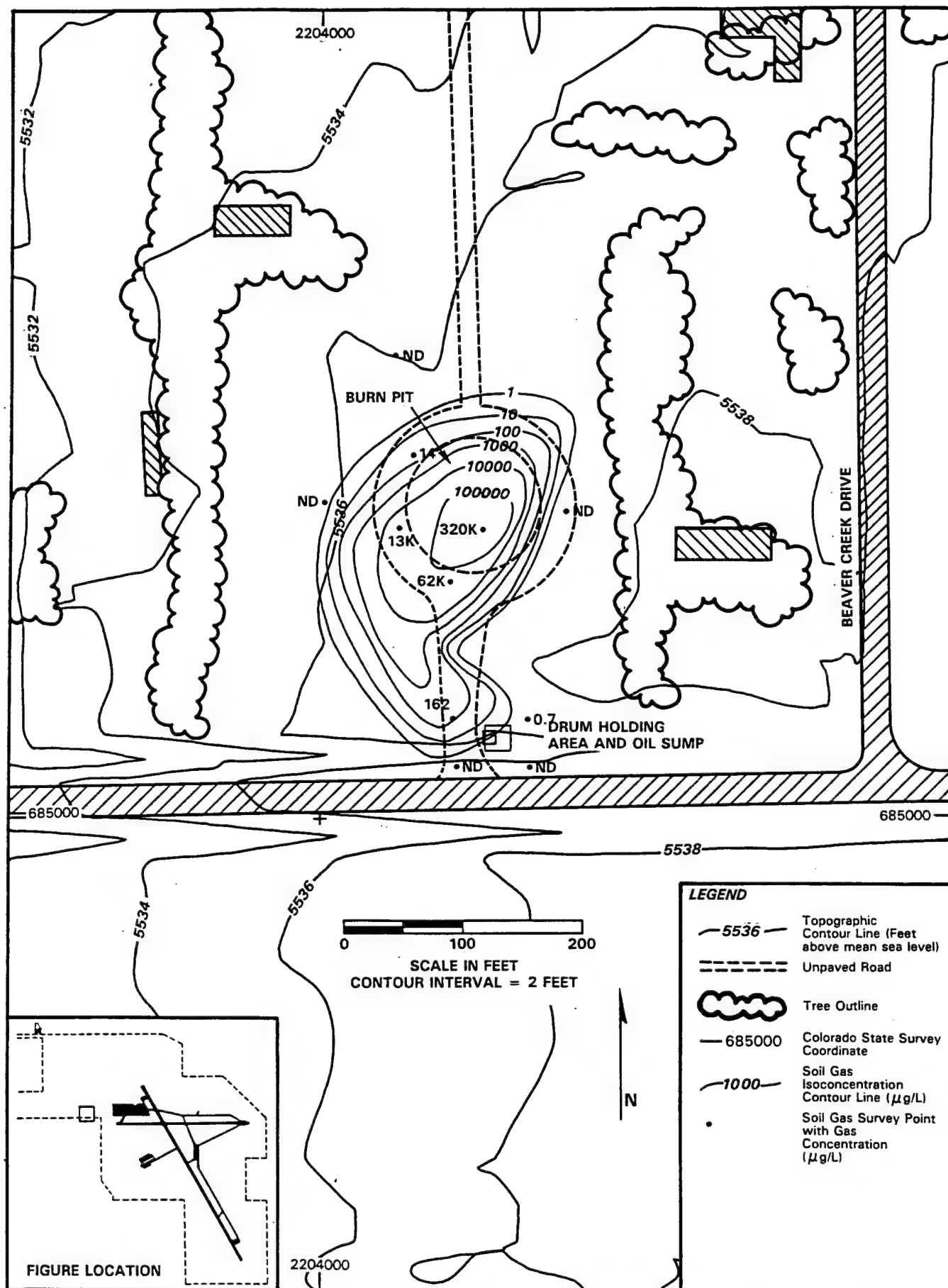


Figure 7-8 Soil Gas Isoconcentration Contour Map of Total Hydrocarbons for Site-4, Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado

7.4.2 Soil Boring Soil Sample Results

Soils from two soil borings (F3B-6 and F3B-7) were sampled during the RI Part 1 at Site 4 with the objective of investigating possible soil contamination and migration of contaminants deeper into the alluvial and Denver Aquifers from the Fire Training Area No. 3 burn pit. Soil samples were collected every 2 ft from the surface to 16 ft BLS. The soil borings were located in the burn pit. Figure 7-1 shows the location of the two soil borings.

The results from the soil boring samples analyzed during the RI Part 1 are presented in Table 7-3a. Ethyl benzene (859 $\mu\text{g/kg}$) and total xylenes (1090 $\mu\text{g/kg}$) were detected in F3B-6 from 0 to 2 ft BLS. The two analytes were detected at decreasing concentrations with depth in all other soil samples from F3B-6 (e.g., total xylenes were detected at 29.0 $\mu\text{g/kg}$ in the soil sample from 14 to 16 ft BLS). Total xylenes were detected in the soil sample from 0 to 2 ft BLS in soil boring F3B-7. The sample from 0 to 2 ft BLS in F3B-6 was the only sample analyzed for semivolatile organic compounds, and the results show eight compounds detected in this interval (Table 7-3a). All the volatile and semivolatile compounds detected at Site 4 are known to be components of fuel which was used in the burn pit. No other volatile or semivolatile organic compounds were detected in the soils from soil borings at Site 4.

Lead was detected in all soil samples, and most of the concentrations were less than the 95% CI of the background. However, two samples (F3B-6, 0 to 2 ft BLS; F3B-7, 0 to 2 ft BLS) located in or near the fire pit show lead concentrations above the 95% CI of background, but still below the expected background range (Table 3-4). The high lead concentration in this soil possibly results from the fuel used in the burn pit.

These data indicate that the volatile and semivolatile organic compounds could possibly be migrating deeper into the alluvium and entering the groundwater below the Former Fire Training Area No. 3. However, the data also indicate that lead detected in the soil samples is probably precipitating close to the land surface and not migrating deeper into the alluvium.

During the RI Part 2 five 40-ft. boreholes (F3B-9, 11, 12, 14, and 15) were drilled within the burn area and adjacent to the fuel storage area at Site 4. These additional soil borings were drilled to determine the vertical contaminant extent for possible future excavation. Soil samples were collected at 5-ft. intervals and screened on-site by ECS with a Shimadzu 8A GC for toluene ethylbenzene, xylene, methylene chloride and TCE. A minimum of two samples per borehole were sent to NET Pacific for in-depth chemical analysis. In addition, seven samples from the burn area were sent to NET Pacific for lead only analysis. These samples were added to the original statement of work to obtain a better understanding of median lead concentrations at the site. Figure 7-1 shows the locations of the five new boreholes drilled during the RI Part 2.

The results of the on-site GC screening of soils showed elevated concentrations of toluene, ethylbenzene, xylene, and methylene chloride in soil borings (F3B-9, 11, 12, and 14) within the burn pit area. The following is a list of ranges for the five organic compounds screened on-site with the GC; toluene (<5 - 1,600 $\mu\text{g/kg}$), ethylbenzene (<5 - 1,600 $\mu\text{g/kg}$), xylene (<5 - 13,000 $\mu\text{g/kg}$), methylene chloride (<20 - 8,800 $\mu\text{g/kg}$), and TCE (<5 - 15 $\mu\text{g/kg}$). The results for the borehole samples screened on-site are shown on cross-sections B-B', C-C', and D-D' (Figures 7-3, 7-4,

TABLE 7-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 4 - FIRE TRAINING AREA NO. 3, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

ANALYTE	UNITS	Sample #: F3B-6(0-2)				Sample #: F3B-6(4-6)				Sample #: F3B-6(8-10)				Sample #: F3B-6(14-16)			
		Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC
		TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5	TB-5
		FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6	FB-6
		F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ	F3B-7EQ
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)																	
Methylene Chloride	ug/Kg	ND	5.98	ND	5.63	ND	5.65	ND	5.65	ND	5.65	ND	5.59	ND	5.76	ND	5.76
Acetone	ug/Kg	ND	119.56	ND	112.64	ND	113.01	ND	113.05	ND	113.05	ND	111.81	ND	115.11	ND	115.11
Chlorobenzene	ug/Kg	ND	5.98	ND	5.63	ND	5.65	ND	5.65	ND	5.65	ND	5.59	ND	5.76	ND	5.76
Ethyl benzene	ug/Kg	858.88*	5.98	60.49	5.63	27.70	5.65	23.97	5.65	13.31	5.65	5.59	5.59	ND	5.76	ND	5.76
Total Xylenes	ug/Kg	1091.90*	5.98	117.48	5.63	64.65	5.65	45.27	5.65	29.02	5.65	9.15	5.59	ND	5.76	ND	5.76
SEMI-VOLATILE ORGANICS (Method 8270)																	
Nitrobenzene	ug/Kg	853	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	ug/Kg	2954	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	ug/Kg	6589*	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	ug/Kg	455	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	ug/Kg	806	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine	ug/Kg	407	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	ug/Kg	1255	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	ug/Kg	1302	389	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
INORGANICS																	
% MOISTURE	wt %	16	0.58	11	0.55	12	0.55	11	0.55	12	0.55	12	0.55	13	0.57	14	0.57
LEAD	mg/Kg	46	0.58	5.5	0.55	5	0.55	7	0.55	9	0.55	9	0.55	14	0.57	14	0.57

LEGEND

ND - Not Detected

NA - Not Analyzed

* - Concentration is out of linear range

TABLE 7-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 4 - FIRE
TRAINING AREA NO. 3, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1 (CONTINUED)

Sample #:F38-7(4-6) Sample #:F38-7(8-10)Sample #:F38-7(14-16)Sample #:F3U-3(8-10)Sample #:F3U-3(8-10)DUPSample #:F3U-3(18-20)																					
		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC		Assoc. QA/QC	
		TB-8		TB-8		TB-8		TB-8		TB-8		TB-8		TB-8		TB-8		TB-8		TB-8	
		FB-6		FB-6		FB-6		FB-6		FB-6		FB-6		FB-6		FB-6		FB-6		FB-6	
		F38-7EQ		F38-7EQ		F38-7EQ		F38-7EQ		F38-7EQ		F38-7EQ		F38-7EQ		F38-7EQ		F3U-3EQ		F3U-3EQ	
ANALYTE	UNITS	ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS	
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)																					
Methylene Chloride	ug/Kg	ND	5.90	ND	5.81	ND	5.81	ND	5.25	ND	5.88	ND	5.88	ND	5.85	ND	5.85	ND	5.55	ND	5.55
Acetone	ug/Kg	ND	117.98	ND	116.21	ND	116.21	ND	104.95	ND	117.55	ND	117.55	ND	117.05	ND	117.05	ND	110.91	ND	110.91
Chlorobenzene	ug/Kg	ND	5.90	ND	5.81	ND	5.81	ND	5.25	ND	5.88	ND	5.88	ND	5.85	ND	5.85	ND	5.55	ND	5.55
Ethyl benzene	ug/Kg	ND	5.90	ND	5.81	ND	5.81	ND	5.25	ND	5.88	ND	5.88	ND	5.85	ND	5.85	ND	5.55	ND	5.55
Total Xylenes	ug/Kg	ND	5.90	ND	5.81	ND	5.81	ND	5.25	ND	5.88	ND	5.88	ND	5.85	ND	5.85	ND	5.55	ND	5.55
SEMI-VOLATILE ORGANICS (Method 8270)																					
Nitrobenzene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
Naphthalene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
2-Methylnaphthalene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
Acenaphthylene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
Fluorene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
N-Nitrosodiphenylamine	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
Phenanthrene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
Anthracene	ug/Kg	NA		NA		NA		NA		ND	318	ND	318	ND	366	NA	366	NA		NA	
INORGANICS																					
% MOISTURE	wt %	15	0.58	14	0.58	4.7	0.58	4.7	0.52	15	0.58	9.7	0.58	15	0.58	9.8	0.58	15	0.58	9.8	0.58
LEAD	mg/Kg	10		8.8		4.2		4.2		9.9		9.7		8.3		8.3		8.3		8.3	

LEGEND

ND- Not Detected

NA- Not Analyzed

TABLE 7-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 4 - FIRE
TRAINING AREA NO. 3, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1 (CONTINUED)

Sample #:F3U-3(25-26)Sample #:F3U-3(34,5-36)Sample #:F3U-4(8-10)Sample #:F3U-4(24-26)Sample #:F3U-4(38-40)Sample #:F3U-4(44-46)													
		Assoc. QA/QC	TB-8	TB-8	Assoc. QA/QC	TB-5	TB-5	Assoc. QA/QC	TB-5	TB-5	Assoc. QA/QC	TB-5	TB-5
			FB-7	FB-7		FB-6	FB-6		FB-6	FB-6		FB-6	FB-6
			F3U-3EQ	F3U-3EQ		F3B-7EQ	F3B-7EQ		F3B-7EQ	F3B-7EQ		F3B-7EQ	F3B-7EQ
ANALYTE	UNITS	ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING	
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT
VOLATILE ORGANICS (Method 8240)													
Methylene Chloride	ug/Kg	ND	5.98	ND	5.71	ND	5.89	ND	5.28	ND	5.70	ND	5.91
Acetone	ug/Kg	ND	119.63	ND	114.26	ND	117.79	ND	105.69	ND	114.06	ND	118.29
Chlorobenzene	ug/Kg	ND	5.98	ND	5.71	ND	5.89	ND	5.28	ND	5.70	ND	5.91
Ethyl benzene	ug/Kg	ND	5.98	ND	5.71	7.96	5.89	7.52	5.28	ND	5.70	ND	5.91
Total Xylenes	ug/Kg	ND	5.98	ND	5.71	16.87	5.89	13.06	5.28	10.80	5.70	ND	5.91
SEMI-VOLATILE ORGANICS (Method 8270)													
Nitrobenzene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
Naphthalene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
2-Methylnaphthalene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
Acenaphthylene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
Fluorene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
N-Nitrosodiphenylamine	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
Phenanthrene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
Anthracene	ug/Kg	NA		ND	375	NA		NA		NA		ND	385
INORGANICS													
% MOISTURE	wt %	16		12		7.8		4.7		13		15	
LEAD	mg/Kg	13	0.58	3.3	0.56	11	0.52	2.4	0.5	3.7	0.53	8.1	0.57

LEGEND

ND- Not Detected
NA- Not Analyzed

TABLE 7-3a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 4 - FIRE
TRAINING AREA NO. 3, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1 (CONTINUED)

Sample #:F3W-5(4-6) Sample #:F3W-5(8-10)Sample #:F3W-5(28-30)Sample #:F3W-5(28-30)DUPSample #:F3W-5(34-36)																					
ANALYTE		UNITS		ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS		REPORTING ANALYSIS	
				RESULT		LIMIT		RESULT		LIMIT		RESULT		LIMIT		RESULT		LIMIT		LIMIT	
VOLATILE ORGANICS (Method 8240)																					
	Methylene Chloride	ug/Kg	ND	5.56	7.45	5.45	ND	5.58	ND	5.58	ND	5.90	13.31	5.22							
	Acetone	ug/Kg	ND	111.26		108.91	ND	111.69	145.17	117.91	ND	104.47									
	Chlorobenzene	ug/Kg	ND	5.56	ND	5.45	ND	5.58	ND	5.90	ND	5.22									
	Ethyl benzene	ug/Kg	ND	5.56	ND	5.45	ND	5.58	ND	5.90	ND	5.22									
	Total Xylenes	ug/Kg	ND	5.56	ND	5.45	ND	5.58	ND	5.90	ND	5.22									
SEMI-VOLATILE ORGANICS (Method 8270)																					
	Nitrobenzene	ug/Kg	NA		NA		NA		NA		NA		344								
	Naphthalene	ug/Kg	NA		NA		NA		NA		NA		344								
	2-Methylnaphthalene	ug/Kg	NA		NA		NA		NA		NA		344								
	Acenaphthylene	ug/Kg	NA		NA		NA		NA		NA		344								
	Fluorene	ug/Kg	NA		NA		NA		NA		NA		344								
	N-Nitrosodiphenylamine	ug/Kg	NA		NA		NA		NA		NA		344								
	Phenanthrene	ug/Kg	NA		NA		NA		NA		NA		344								
	Anthracene	ug/Kg	NA		NA		NA		NA		NA		344								
INORGANICS																					
	% MOISTURE	wt %	10		8.2	0.54	10		15		4.3										
	LEAD	mg/Kg	15	0.55	9.3	0.54	11	0.55	14	0.58	4.6	0.5									

LEGEND

ND - Not Detected
NA - Not Analyzed

and 7-5). The on-site GC results are also presented in Appendix G-1.

In general, soil contamination was detected in each borehole within the burn pit area from 0 to 7 ft. BLS. However, boreholes F3B-12 and F3B-14 showed evidence of soil contamination to 41.5 and 36.5 ft. BLS, respectively. None of the five compounds screened on-site were detected in the borehole (F3B-15) drilled adjacent to the fuel storage area.

All soil samples collected at Site 4 - Fire Training Area No. 3 during the RI Part 2 that were sent to the laboratory (NET Pacific) were analyzed for VOCs, SVOCs, and lead. The locations of the borehole soil samples sent to the laboratory are also shown on cross-sections B-B', C-C', and D-D' (Figures 7-3, 7-4, and 7-5). The laboratory results for RI Part 2 are summarized in Table 7-3b.

The results from the laboratory analysis of borehole soil samples taken during the RI Part 2 at Site 4 also show that the soils below the burn area are contaminated. VOC results indicate the presence of ethylbenzene, xylene, and methylene chloride in six of the ten soil samples analyzed in the laboratory for VOCs. The following ranges for ethylbenzene (ND - 1100 µg/kg), xylene (ND - 170,000 µg/kg), and methylene chloride (ND - 590 µg/kg) were detected in soil samples from boreholes (F3B-9, 11, 12, and 14) drilled within the burn area (Figure 7-1). No VOC compounds were detected in the borehole drilled adjacent to the fuel storage area (outside the burn area). VOC TICs were also detected in six soil samples from the burn area with concentrations ranging from 162,500 to 949,000 µg/kg.

SVOC results indicate the presence of naphthalene, 2-methylnaphthalene, and phenanthrene in six of ten soil samples analyzed in the laboratory for SVOCs. The following ranges for naphthalene (ND - 2,500 µg/kg), 2-methylnaphthalene (ND - 6,700 µg/kg), and phenanthrene (ND - 510 µg/kg) were detected in soil samples from boreholes (F3B-9, 11, 12, and 14) drilled within the burn area. No identifiable SVOC compounds were detected in F3B-15. SVOC TICs were detected in nine soil samples with concentrations ranging from 140 to 258,600 µg/kg.

Lead concentrations for the 18 soil samples sent to the laboratory ranged from 5.0 to 22.1 mg/kg. The median lead concentration (10.03 mg/kg) is the same as the 95% CI of background (10 mg/kg) established at the base during the RI Part 1.

7.4.3 Monitoring Well Borehole Soil Sample Results

Soil samples were collected in three monitoring well boreholes (F3W-3, F3W-4, and F3W-5) during the RI Part 1 at Site 4. The objective of the soil sampling in monitoring wells was to provide information about possible contamination existing in the soils and possible contaminant migration deeper into the alluvial or Denver Aquifers. Figure 7-1 shows the locations of these monitoring wells.

Table 7-3a summarizes the analytical results for monitoring well soil samples taken during the RI Part 1 at Site 4. Methylene chloride was detected in one well borehole soil sample, but it is considered a laboratory contaminant and is not indicative of contamination at this location. Acetone was detected in one well borehole soil sample (F3W-4) from 0 to 2 ft BLS but because it was present in field QA/QC samples, it is not considered an environmental contaminant at this site. Ethyl benzene (7.96 µg/kg) and total xylenes (16.9 µg/kg) were detected in the soil sample from 8 to 10 ft BLS

Table 7-3B. Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 4 - Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2

SAIC ID Number	F3B-9(1.0-1.5)	F3B-9(7.5-8.0)	F3B-9(12.5-13.0)	F3B-9(17.0-17.5)	F3B-9(17.5-18.0)	F3B-11(1.0-1.5)
Laboratory ID Number	11860	12178	12179	12180	11861	11939
Collection Date	07/31/91	07/31/91	07/31/91	07/31/91	07/31/91	08/01/91
Associated Field QC Sample	F3-TB01	F3-TB01	F3-TB01	F3-TB01	F3-TB01	F3-TB02
Parameter	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02
Units	LF-EB01	LF-EB01	LF-EB01	LF-EB01	LF-EB01	LF-EB01
Trace Metals (SOW 3/90)						
Lead	10.4 J(N)	8.5 J(N,LCS)	6.4 J(N,LCS)	5.0 J(N,LCS)	5.9 J(N)	6.0 J(N)
Volatiles Organics (SOW 3/90)						
Methylene Chloride	800 U(MB)	NA	NA	NA	28 U(MB)	1600 UJ(S,MB)
Ethylbenzene	250 U	NA	NA	NA	5 U	500 UJ(S)
Xylene (total)	250 U	NA	NA	NA	5 U	8900 EJ(S)
TIC Total	163100 (9)	NA	NA	NA	0 (0)	0 (0)
Semivolatile Organics (SOW 3/90)						
Naphthalene	580	NA	NA	NA	350 U	NA
2-Methylnaphthalene	1300	NA	NA	NA	350 U	NA
Phenanthrene	380 U	NA	NA	NA	350 U	NA
TIC Total	47120 (20)	NA	NA	NA	140 (1)	NA
U - compound/element was included in analysis, but was not detected						
NA - not analyzed						
N - spike sample recovery outside control limits						
TIC - tentatively identified compounds (number of non-TCL compounds detected)						
MB - compound also detected in the associated laboratory method blank						
IS - internal standard						
J - estimated value						
LCS - laboratory control sample						

Table 7-3B. Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 4 - Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2 (Continued)

SAIC ID Number	F3B-11(1.0-1.5)R/DL	F3B-11(1.5-2.0)	F3B-11(1.5-2.0)R/DL	F3B-11(6.5-7.0)	F3B-11(21.5-22.0)	F3B-11(31.5-32.0)
Laboratory ID Number	11939R/DL	11940	11940R/DL	12181	12182	11941
Collection Date	08/01/91	08/01/91	08/01/91	08/01/91	08/01/91	08/01/91
Associated Field QC Sample	F3-TB02	F3-TB02	F3-TB02	F3-TB02	F3-TB02	F3-TB02
Parameter	LF-FB01.02	LF-FB01.02	LF-FB01.02	LF-FB01.02	LF-FB01.02	LF-FB01.02
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Trace Metals (SOW 3/90)						
Lead	NA	22.1 J(N)	NA	10.0 J(N,LCS)	92 J(N,LCS)	6.7 J(N)
Volatiles Organics (SOW 3/90)						
Methylene Chloride	15000 U(TB)	1200 U(I,IS,MB)	19000 U(TB)	NA	NA	21 U(MB)
Ethylbenzene	5000 U	500 U(I,IS)	5000 U	NA	NA	5 U
Xylene (total)	170000	62000 EJ(IS)	170000	NA	NA	5 U
TIC Total	942000 (9)	0 (0)	949000 (9)	NA	NA	0 (0)
Semi-volatile Organics (SOW 3/90)						
Naphthalene	2000 D	NA	2500 D	NA	NA	420 U
2-Methylnaphthalene	2300 D	NA	6700 D	NA	NA	420 U
Phenanthrene	1700 U	NA	510 DJ	NA	NA	420 U
TIC Total	258600 (20)	NA	179700 (20)	NA	NA	210 (1)

U - compound/element was included in analysis, but was not detected

NA - not analyzed

N - spike sample recovery outside control limits

TB - compound also detected in the associated trip blank

D - analysis was evaluated at a secondary dilution factor

TIC - tentatively identified compounds (number of non-TCL compounds detected)

MB - compound also detected in the associated laboratory method blank

LCS - laboratory control sample

IS - internal standard

J - estimated value

**Table 7-3B. Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 4 - Fire Training Area No. 3,
Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2 (Continued)**

SAIC ID Number	F3B-12(1.5-2.0)	F3B-12(1.5-2.0)R	F3B-12(21.5-22.0)	F3B-12(41.0-41.5)	F3B-14(4.5-5.0)	F3B-14(10.5-11.0)
Laboratory ID Number	11942	11942R	11943	12183	11954	12184
Collection Date	08/02/91	08/02/91	08/02/91	08/02/91	08/05/91	08/05/91
Associated Field QC Sample	F3-TB02	F3-TB02	F3-TB02	F3-TB02	F3-TB03	F3-TB03
Parameter	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02	LF-FB01,02
Units	LF-EB01	LF-EB01	LF-EB01	LF-EB01	LF-EB01	LF-EB01
Trace Metals (SOW 3/90)						
Lead	mg/kg	21.0 J(N)	NA	14.6 J(N)	7.0 J(N,LCS)	14.6 J(N)
Volatile Organics (SOW 3/90)						
Methylene Chloride	µg/kg	590 J(IS)	19000 U(TB)	NA	250 U	NA
Ethylbenzene	µg/kg	500 UJ(IS)	5000 U	1100	250 U	NA
Xylene (total)	µg/kg	53000 EJ(IS)	110000	20000 E	250 U	NA
TIC Total	µg/kg	0 (0)	836000 (9)	290000 (9)	162500 (9)	NA
Semivolatile Organics (SOW 3/90)						
Naphthalene	µg/kg	930	NA	440	390 U	NA
2-Methylnaphthalene	µg/kg	1700	NA	640	490	NA
Phenanthrene	µg/kg	340 U	NA	350 U	390 U	NA
TIC Total	µg/kg	46340 (20)	NA	40210 (20)	35930 (20)	NA

U - compound/element was included in analysis, but was not detected

NA - not analyzed

N - spike sample recovery outside control limits

E(organics) - concentration exceeded the calibration range of the instrument

TIC - tentatively identified compounds (number of non-TCL compounds detected)

MB - compound also detected in the associated laboratory method blank

LCS - laboratory control sample

IS - internal standard

J - estimated value

Table 7-3B. Summary of Inorganic and Organic Compounds Detected in Soil Samples at Site 4 - Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2 (Continued)

SAIC ID Number	F3B-14(36.5-37.0)	F3B-14(36.5-37.0)RE	F3B-15(6.5-7.0)	F3B-15(16.5-17.0)
Laboratory ID Number	11955	11955RE	11956	11957
Collection Date	08/05/91	08/05/91	08/06/91	08/06/91
Associated Field QC Sample	F3-TB03 LF-FB01.02 LF-EB01	F3-TB03 LF-FB01.02 LF-EB01	F3-TB03 LF-FB01.02 LF-EB01	F3-TB03 LF-FB01.02 LF-EB01
Parameter	Units			
Trace Metals (SOW 3/90)				
Lead	mg/kg	3.3 J(N)	9.9 J(N)	8.8 J(N)
Volatile Organics (SOW 3/90)				
Methylene Chloride	µg/kg			
Ethylbenzene	µg/kg	9 U(MB)	16 U(MB)	5 U
Xylene (total)	µg/kg	5 U	5 U	5 U
TIC Total	µg/kg	0 (0)	0 (0)	0 (0)
Semi-volatile Organics (SOW 3/90)				
Naphthalene	µg/kg	NA		350 U
2-Methylnaphthalene	µg/kg	NA		350 U
Phenanthrene	µg/kg	NA		350 U
TIC Total	µg/kg	NA		350 U
U - compound/element was included in analysis, but was not detected				
NA - not analyzed				
N - spike sample recovery outside control limits				
EHT - extraction holding time exceeded				
TIC - tentatively identified compounds (number of non-TCL compounds detected)				
MB - compound also detected in the associated laboratory method blank				
J - estimated value				

from F3W-4. Deeper samples from the same well borehole indicate decreasing concentrations until the sample at 44 to 46 ft BLS where no volatile organic compounds were detected. No other volatile organic compounds, and no semivolatile organic compounds were detected in well borehole soils at Site 4. Lead was detected in the soils, but was below the 95% CI for the background or was below the expected natural range. These data indicate that the contaminants are spreading vertically from the fire pit to approximately 40 ft BLS.

During the RI Part 2 at Site 4, soil samples were collected at 5-ft. intervals from the three new monitoring well boreholes (F3W-8, 10, and 13) drilled downgradient of the burn pit area. Each sample was screened on-site by ECS with a Shimadzu 8A GC for toluene, ethylbenzene, xylene, methylene chloride and TCE. Figure 7-1 shows the locations of the three new monitoring well boreholes.

No trends in contaminant concentrations were observed from the on-site GC screening of monitoring well borehole soil samples. The results for on-site screening showed only minor concentrations of xylene (14 $\mu\text{g/kg}$) detected in F3W-10 from 31.0 to 31.5 ft. BLS and TCE (17 $\mu\text{g/kg}$) detected in F3W-13 from 46.5 to 47.0 ft. BLS. None of the five organic compounds screened on-site were detected in any of the other monitoring well borehole soil samples. The results for monitoring well borehole soil samples screened on-site are shown on cross-sections B-B', C-C', and D-D' (Figures 7-3, 7-4, and 7-5). The on-site GC results are also presented in Appendix G-1. Because of the use of on-site GC screening no monitoring well borehole soil samples were sent to NET Pacific for in-depth analysis during the RI Part 2.

7.4.4 Groundwater Sample Results

Groundwater samples were collected from the three monitoring wells installed during the RI Part 1. All three wells were installed with screened intervals in the Denver Aquifer. The objective of the groundwater sampling was to determine if the groundwater under Site 4 has been contaminated from Fire Training Area No. 3.

Table 7-4a summarizes the analytes detected in groundwater during the RI Part 1 at Site 4. No volatile or semivolatile organic compounds were detected in the groundwater samples. No lead was detected in the groundwater samples. Results from cation analysis show magnesium exceeding State of Colorado drinking water standards, but within concentration ranges expected for the Denver Aquifer near the Base (Hillier et al. 1983). Calculated hardness is higher than background, but concentrations are comparable with other groundwater samples collected during the RI and other wells in the Denver Aquifer near the Base. Nitrate concentrations in groundwater from F3W-3 exceed the State of Colorado standard (Colorado Department of Health 1971), and are outside expected concentration ranges for the Denver Aquifer in this area (Hillier et al. 1983). No cause was determined for high nitrate concentrations, but the well F3W-3 located upgradient of other wells show high concentrations of nitrate. Sulfate concentrations exceeded State of Colorado standards in all wells at Site 4, but were below expected concentration ranges in this area (Hillier et al. 1983). High concentrations of these analytes are possibly caused by the high amount of suspended solids in the samples.

TABLE 7-4a. SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES AT SITE 4 - FIRE TRAINING AREA NO. 3, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
REMEDIAL INVESTIGATION: PART 1

		Sample #:F3W-3	Sample #:F3U-4	Sample #:F3U-5
		Assoc. QA/QC	Assoc. QA/QC	Assoc. QA/QC
		TB-16	TB-16	TB-16
		F8-20	F8-20	F8-20
		F3W-5EQ(GW)	F3U-5EQ(GW)	F3U-5EQ(GW)
ANALYTE	UNITS	REPORTING ANALYSIS RESULT	REPORTING ANALYSIS LIMIT	REPORTING ANALYSIS RESULT
FIELD ANALYSIS				
pH	units	7.1	6.74	6.94
Temperature	deg. C	10.0	11	13
Conductivity	umhos/cm	2230	1580	1890
VOLATILE ORGANICS (Method 8240)				
		ND	ND	ND
SEMI-VOLATILE ORGANICS (Method 8270)				
		ND	ND	ND
INORGANICS				
CALCIUM	ug/L	290000	50	180000
CHLORIDE	mg/L	86.6/86.2		42.9
MAGNESIUM	ug/L	47000	200	33000
NITRATE	mg/L	43.5		7.1
NITRITE	mg/L	0.04		0.01
SULFATE	mg/L	933/933		497
PHOSPHOROUS	mg/L	0.23/0.22		0.04
POTASSIUM	ug/L	2800	19	2700
SODIUM	ug/L	210000	900	140000

LEGEND

ND- Not Detected

Specific conductivity and pH were measured for each groundwater sample during the RI Part 1. The measured specific conductivities varied between 1580 and 2230 $\mu\text{S}/\text{cm}$, which may be caused, in part, by dissolution of suspended solids in the sample. The measured pH varied between 6.74 to 7.10.

During the RI Part 2 groundwater samples were collected from three existing wells (F3W-3, F3W-4 and F3W-5) and three newly installed wells (F3W-8, F3W-10, and F3W-13) at Site 4. These additional wells were installed to determine the potential for contaminant migration in the groundwater downgradient of the source area. Monitoring wells installed at Site 4 during the RI Part 1 investigation were not located directly downgradient of the source area (burn pit). Figure 7-1 shows the locations of all the groundwater monitoring wells at Site 4.

All groundwater samples collected at Site 4 - Fire Training Area No. 3, during the RI Part 2 were analyzed in the laboratory (NET Pacific) for VOCs, SVOCs, and lead. Table 7-4b summarizes the results from the groundwater samples collected at Site 4 during the RI Part 2.

VOC results indicate the presence of benzene (1 $\mu\text{g}/\text{L}$) and xylene (2 $\mu\text{g}/\text{L}$) in monitoring well F3W-8. Similar concentrations (benzene, 2 $\mu\text{g}/\text{L}$ and xylene, 4 $\mu\text{g}/\text{L}$) were also detected in the duplicate sample from F3W-8. However, all of these concentrations are considered estimated values. The mass spectral data indicate the presence of compounds that meet the identification criteria for benzene and xylene but the result is less than the sample quantitation limit and greater than zero. In addition these concentrations for benzene are well below the MCL (5 $\mu\text{g}/\text{L}$). One VOC TIC (23 $\mu\text{g}/\text{L}$) was detected in the groundwater sample from F3W-5. No other VOC compounds were detected in the groundwater samples during the RI Part 2 at Site 4.

Identifiable SVOCs were not detected in any of the Site 4 groundwater samples submitted to the laboratory with the exception of SVOC TICs. SVOC TICs were detected in each groundwater sample with concentrations ranging from 14 to 58 $\mu\text{g}/\text{L}$.

Lead was detected in F3W-13 with a concentration of 114 $\mu\text{g}/\text{L}$ while lead concentrations in the other five wells at Site 4 ranged from 3.3 to 19.6 $\mu\text{g}/\text{L}$. Since groundwater samples were not filtered this apparently elevated concentration of lead maybe due to suspended solids (turbidity) in the sample. Therefore, on 11/6/91 F3W-13 was purged and resampled for lead. The concentration of lead in the second sample F3W-13-02W was 38.25 $\mu\text{g}/\text{L}$. Although this lead concentration is higher than the other samples from Site 4, it is below the MCL for lead (50 $\mu\text{g}/\text{L}$).

Specific conductivity, pH, and temperature were measured for each groundwater sample from Site 4 during the RI Part 2. The specific conductivity varied between 1400 and 2700 $\mu\text{mhos}/\text{cm}$, which may be caused by dissolution of suspended solids in the sample. Sample pH varied from 6.85 to 7.30 (neutral) while sample temperature ranged from 14.5 to 16°C.

Table 7-4B. Summary of Inorganic and Organic Compounds Detected in Groundwater Samples at Site 4 - Fire Training Area No. 3, Colorado Air National Guard, Buckley Field, Aurora, Colorado, Remedial Investigation: Part 2

SAIC ID Number	F3W-3-02W	F3W-4-02W	F3W-5-02W	F3W-8-01W	F3W-8-02W	F3W-10-01W	F3W-13-01W
Laboratory ID	12119	12120	12121	12130	12131	12135	12132
Collection Date	08/15/91	08/15/91	08/15/91	08/19/91	08/19/91	08/20/91	08/19/91
Associated Field QC Sample	F3-TB05 LF-FB01.02 F3-EB03	F3-TB05 LF-FB01.02 F3-EB03	F3-TB05 LF-FB01.02 F3-EB03	F3-TB07 LF-FB01.02 F3-EB03	F3-TB07 LF-FB01.02 F3-EB03	F3-TB08 LF-FB01.02 F3-EB03	F3-TB07 LF-FB01.02 F3-EB03
Parameter							
Trace Metals (SOW 3/90)							
Lead	8.3	11.4	3.3	18.8	19.6	7.4	114
Units							
µg/L							
Volatile Organics (SOW 3/90)							
Benzene	5 U	5 U	5 U	1 J	2 J	5 U	5 U
Xylene (total)	5 U	5 U	5 U	2 J	4 J	5 U	5 U
TIC Total	0 (0)	0 (0)	23 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Semivolatile Organics (SOW 3/90)							
TIC Total	14 (2)	58 (3)	18 (4)	21 (2)	20 (2)	14 (2)	29 (2)
µg/L							
U - element/compound was included in analysis, but was not detected							
J - concentration is considered estimated; mass spectral data indicate the presence of a compound that meets the identification criteria, but the result is less than the sample quantitation limit and greater than zero							
TIC - tentatively identified compound (number of non - TCL compounds detected)							

SAIC ID Number	F3W-13-02W*
Laboratory ID	14342
Collection Date	11/06/91
Associated Field QC Sample	
Parameter	Units
Trace Metals (SOW 3/80)	
Lead	µg/L 38.25
Volatile Organics (SOW 3/80)	
Benzene	µg/L
Xylene (total)	µg/L
TIC Total	µg/L
Semivolatile Organics (SOW 3/80)	
TIC Total	µg/L

* Monitoring well F3W-13 was resampled and analyzed for lead only

7.5 SUMMARY OF FINDINGS

The soil-gas survey data indicate that an area of volatile organic compounds exists surrounding the fire pit area and extending towards the oil sump. Volatile compounds detected were total hydrocarbons, benzene, toluene, and total xylenes.

Volatile and semivolatile organic compounds were detected in six soil borings (F3B-6, F3B-7, F3B-9, F3B-11, F3B-12, and F3B-14) and one monitoring well soil boring (F3W-4) at depths up to 46 ft. These data indicate that the contaminants are migrating vertically in the soil horizon. Lead was detected in all soil samples, but at concentrations well within the natural regional background range (2.0 - 200 mg/kg, Dragun, 1988).

Lead was detected in the groundwater above the MCL in one well (F3W-13). However, this well was resampled and the result was below the MCL. The elevated concentration of lead was probably due to suspended solids in the sample. Nitrate was detected at concentrations above MCLs and the expected range in one well (F3W-4). The occurrence of high nitrate appears to be anomalous, because the well was upgradient from other wells at the site. Nitrate was not detected at high concentrations in other wells at the site.

7.6 RISK ASSESSMENT RESULTS

7.6.1 Groundwater Consumption Risks

The evaluation of groundwater consumption risks is based on data derived during RI Parts 1 and 2. In order to examine the magnitude of this contamination a summary table, Table 7-5, has been prepared showing mean and maximum levels of inorganic toxicants in groundwater at Site 4. For comparison, the applicable or relevant and appropriate requirements (ARAR; i.e., federal and state water-quality criteria and standards) are included. Since the presence of organic substances during RI Part 2 is questionable (see Section 7.4.4), there are no ARAR tables for that type of contaminant. As specified in the Superfund Amendments and Reauthorization Act of 1986 (SARA), on-site remedial actions are required to attain ARARs unless such requirements are formally waived.

Referring to Table 7-5, it can be observed that the reported levels of nitrate and sulfate exceed ARAR levels or TBC guidelines. The TBC guideline for sulfate is an SMCL that is not enforceable and is set based on secondary (non-health-related) criteria. The high nitrate level only occurs in well F3W-3 which is hydraulically upgradient from the bermed fire pit area (see Section 7.4.4). The reported concentrations of nitrite does not exceed the ARAR level. There are no ARAR levels or TBC guidelines for calcium, chloride, magnesium, phosphorous, potassium, and sodium. Since all detected quantities of organic and inorganic compounds are below ARAR levels or TBC guidelines, or there is a reasonable explanation (not related to hazardous material disposal or handling practices) for the occurrence of elevated levels - a risk characterization was not conducted for the groundwater-consumption pathway.

TABLE 7-5. ARARs FOR INORGANIC CHEMICALS FROM SITE 4 GROUNDWATER AT THE BUCKLEY ANGB

Inorganic Constituent	Mean Concentration (µg/L)	Maximum Concentration (µg/L)	Drinking (a) Water MCL (µg/L)	Drinking (b) Water MCL (µg/L)	AWQC (c) Adjusted for Drinking Water Only (µg/L)	Federal Water Health Advisories (g)		
						Colorado Drinking Water Standards (µg/L)	One-Day 10 kg (h) (µg/L)	Ten-Day 10 kg (h) (µg/L)
Calcium	223,333	290,000						
Chloride	65,700	86,600						
Lead	23	114(k)	50					
Magnesium	133,333	320,000						
Nitrate	20,100	43,500	10,000	10,000(d)		10,000	111,000	111,000
Nitrite	30	50		1,000(d)				
Phosphorous	30	620						
Potassium	2,767	2,800						
Sodium	173,333	210,000						
Sulfate	705,000	933,000	250,000(e)					

(a) Maximum Contaminant Levels established under the Safe Drinking Water Act.

(b) Maximum Contaminant Level Goal established under the Safe Drinking Water Act.

(c) Ambient Water Quality Criteria established under the Clean Water Act, adjusted for drinking water.

(d) Proposed MCL or MCLG.

(e) Secondary Maximum Contaminant Level (SMCL) established under the Safe Drinking Water Act – not an ARAR.

(f) Criterion established based on taste and odor effects (organoleptic) not human health effects.

(g) Federal Drinking Water Health Advisories are not ARARs, but values to be considered (TBC) in evaluating the significance of observed levels of contamination in drinking water supplies.

(h) Drinking Water Health Advisory for a 10 kg child.

(i) Drinking Water Health Advisory for a 70 kg adult.

(j) Since one sample was taken from only one well the mean and the maximum were assumed to the reported values for that one particular well.

(k) High level value likely due to suspended solids; lead detected at 38.2 µg/L when resampled (see Section 7.4.4).

7.6.2 Soil Exposure Risks

Table 7-6 presents the results of the risk assessment for Site 4 soils. The table first provides a summary of mean levels of chemical contaminants observed in soils and sediments at the site under investigation. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects which were calculated taking into account the calculated dose. The third column describes the target organs for potential noncarcinogenic effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

As shown in Table 7-6, none of the hazard quotients for any subject chemical exceed 1.0. In addition, the hazard index for combined exposure across chemicals is also less than 1.0. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to compounds in soils or sediments for Base personnel, or for children hypothetically exposed offsite. Only two potentially carcinogenic chemicals were detected in soils under evaluation. Looking again at the summary table, it can be seen that the excess lifetime risk of cancer does not exceed 4×10^{-6} . Based on EPA guidelines under CERCLA/SARA, and given the very conservative exposure assumptions used in the assessment, this risk level would be considered to fall within the acceptable range.

7.7 CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the RI data collected at Site 4 confirmed the subsurface soil contamination detected during the SI. The soil-gas survey revealed a 170 ft by 260 ft area of contamination, consisting principally of petroleum hydrocarbons. The center of this contamination is located within the burn pit area and extends southward in the direction of the waste fuel storage area. Measured volatile soil-gas contamination consists primarily of benzene, toluene, and xylene, which are components of fuel burned at the pit. Only limited levels of chlorinated organic solvents, TCE and PCE, were detected. The area of soil contamination within the burn area was further defined by five soil borings. All five soil borings drilled within the burn area showed high levels of volatile and semivolatile contamination at the surface which decreased with depth. Results from the laboratory analysis of borehole soil samples showed that soil contamination extended to 22.0 ft BLS in F3B-12. However, the on-site GC results showed that soil contamination had extended to 41.5 and 36.5 ft BLS in F3B-12 and F3B-14, respectively. Analysis of samples from soil borings outside the burn area (F3B-7 and F3B-15) showed low levels of petroleum hydrocarbon contamination present only to a depth of 2 ft (F3B-7).

Table 7-6. Risk Characterization for Site 4: Soil Exposure

COMPOUND	Mean Levels in Soil (a) (ug/L)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic				
Beryllium				
Cadmium				
Chromium				
Copper				
Lead	10.08	6E-03	CNS, Kidney	
Mercury				
Nickel				
Phosphorous				
Selenium				
Silver				
Thallium				
Zinc				
ORGANICS				
Acenaphthylene	0.27	3.9E-06	Skin	
Acetone	0.12	1.0E-06	Liver, Kidney	
Anthracene	0.32	9.2E-07	Skin	
Ethylbenzene	0.09	8.1E-07	Skin, Liver, Kidney	
Fluorene	0.29	6.2E-06		
2-Hexane				
Methylene Chloride	0.76	1.1E-06	Liver	4.0E-10
2-Methylnaphthalene	1.02	Data Inadequate for Quantitative Risk Assessment		
Naphthalene	0.58	1.2E-04	Eye, Blood	
Nitrobenzene	0.29	5.1E-04	Blood	
N-Nitrosodiphenylamine	0.20			7.0E-07
Phenanthrene	0.30	Data Inadequate for Quantitative Risk Assessment		
1,1,2,2-Tetrachloroethane				
Tetrachloroethylene				
Toluene				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Trichloroethylene				
Xylenes	13.87	1.2E-03	CNS	
Hazard Index: Combined Exposure		7.8E-03		
Excess Lifetime Cancer Risk: Combined Exposure				7.0E-07

- a. Mean based on 41 lead analyses, 34 VOC analyses, and 18 semi-VOC analyses. Mean concentrations were determined treating "not detected" results as if the chemical was present at half the detection limit
- b. Dose calculated assuming ingestion exposure to contaminated surface soil on-site. Exposure assumptions: inadvertent ingestion of 0.1 grams of soil/day, by Base personnel: 70 kg adult exposed 2 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

Deeper samples within both borings showed no site-related contamination. The monitoring well borehole (F3W-4) installed adjacent to the burn pit showed minor levels of petroleum related contamination to a depth of 40 ft. Other monitoring well borehole samples showed no evidence of any site-related contamination.

Very limited site contamination was detected in the groundwater at the site. Estimated concentrations (below the sample quantitation limit but greater than zero) were detected in F3W-8. Other inorganic compounds were detected, but were at levels consistent with naturally occurring background levels.

The results of the five soil borings drilled within the burn area clearly show that soil contamination is present to 22.0 ft BLS. A baseline public health evaluation indicates that there is no significant carcinogenic or noncarcinogenic risk associated with the soil contamination at the site. However, it must be realized that the mean levels of the contaminants used in the risk calculation also include those soil samples taken from outside the burn area (F3B-7 and F3B-15). Therefore, a nontime-critical source removal action for the soil within the burn pit is recommended for Site 4.

8.0 SITE 5 - DRAINAGE DITCH

This section provides information specifically pertaining to Site 5. This includes past investigation activities, RI objectives and activities performed, the results and significance of RI findings, risk assessment results, and conclusions and recommendations. Background information of past activities is provided in Sections 8.1 and 8.2. A complete description of activities and results of IRP Phase II, Stage 1, Part 1 are presented in "Installation Restoration Program, Phase II-Confirmation/Quantification Stage 1, Buckley Air National Guard Base" (Dames & Moore 1986).

8.1 SITE DESCRIPTION AND PREVIOUS WORK

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley ANGB and to assess potential for contaminant presence and migration. This phase consisted primarily of interviews and record review. The purpose of this phase was to determine the uses of all associated buildings and areas around this ditch.

The Storm Drainage System, which serves the aircraft apron and associated hangers and buildings, consists of a system of pipes, culverts, and open ditches. The drainage system is discharged to East Tollgate Creek. Between 1942 and 1982, aircraft were washed and painted on the apron south of Building 801. The apron was washed with water that either infiltrated or flowed off northeastward to a drainage ditch, which in turn flowed off-base. Fuels, cleaning compounds, ethylene glycol, paints, and strippers were used in this area (Simons, Li, & Associates, Inc. 1982). Later inspection of topographic maps indicated that surface water flow is toward the southwest not the northeast. Therefore, the focus of the RI study centered around the soils to the southwest of the aircraft parking apron and not the drainage ditch which runs north of the site.

IRP Phase II, Stage 1, Part 1, Confirmation/Quantification (Site Inspection)

Field investigations were conducted at Site 5. Activities included drilling, sampling, and logging of three soil borings. Chemical analyses of soil samples was performed.

Chemical analyses of soils from this site (see Table 8-1) indicated that no contamination was present. The previous SI studies did not determine background soil contaminant concentrations, or confirm the presence of contaminants at the site. Information needed to complete data gaps includes soil and surface water characterization and accurate definition of the limits and features of the storm drainage system. Recommendations for further investigation included installing one downgradient well at the Storm Drainage System (Site 5).

TABLE 8-1. ANALYTICAL RESULTS FOR SITE 5 - STORM DRAINAGE SYSTEM

Parameter (Sample Depth-Feet)	Method	Unit	Detection Limit	Soil Samples					
				B-1 (0- 1.5)	B-1 (5- 6.5)	B-2 (0- 1.5)	B-2 (5- 6.5)	B-3 (0- 1.5)	B-3 (5- 6.5)
Lead	239.1 ^a	mg/kg	10	38	25	77	38	34	24
Phenolics	420.2 ^a	mg/kg	1	ND	1	1	ND	ND	3
Total Organic Carbon	415.1 ^a	mg/kg	5	3300	400	4800	2400	4200	1900
Total Organic Halocarbons	9020 ^b	mg/kg	5	ND	ND	ND	ND	ND	ND
Moisture Content	160.3 ^a	Percent	1	17	15	19	18	20	15

2

^a Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

^b Test Methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, Modified for use on 0.1 Corp. Model 610 TOX Analyzer.

ND - indicates value less than detection limits.

Source: Dames & Moore 1986 and 1987. "Installation Restoration Program, Phase II - Confirmation/Quantification, Stage 1."

8.2 REMEDIAL INVESTIGATION ACTIVITIES

Remedial investigation activities were based upon findings of the Preliminary Assessment (Phase I Records Search) and two earlier investigations (Phase II Stage 1, Parts 1 and 2-Confirmation/Quantification). Objectives of the RI were to:

- Determine if contamination of the various environmental media at Site 5 is present
- Identify the source(s) and nature of any contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risk any present contamination pose to public health, thereby determining the need for remedial actions.

RI Part 1 activities performed at Site 5-Storm Drainage System, included collecting six sediment samples southwest of the aircraft parking apron.

Locations of field activities for Site 5 are shown in Figure 8-1. A listing of sampling parameters is presented in Table 8-2. No additional field work was performed during the RI Part 2 at Site 5.

8.3 SITE HYDROGEOLOGY

No drilling activities were performed at this site but the hydrogeologic conditions at the site can be generally hypothesized based upon findings at other sites. The sediments underlying the site are probably similar to those found at nearby Site 4-Fire Training Area No. 3, consisting of a thin surficial layer of loess underlain by relatively thick eolian and Denver Formation sand and small gravel deposits. The water level is probably 40 to 50 ft BLS with a small (~0.001 range) hydraulic gradient in the westerly to northwesterly direction.

8.4 RESULTS AND SIGNIFICANCE OF FINDINGS

8.4.1 Surficial Sediment Sample Results

Six surficial sediments were sampled during the RI Part 1 at Site 5. The objective of sampling these sediments was to determine if contaminated paints, solvents, or other chemical compounds washed into the drainage system from the aircraft apron. The sampling locations are shown in Figure 8-1.

Table 8-3 summarizes the analysis results. Methylene chloride was detected in five of the samples, but this compound is considered a laboratory contaminant and not indicative of environmental

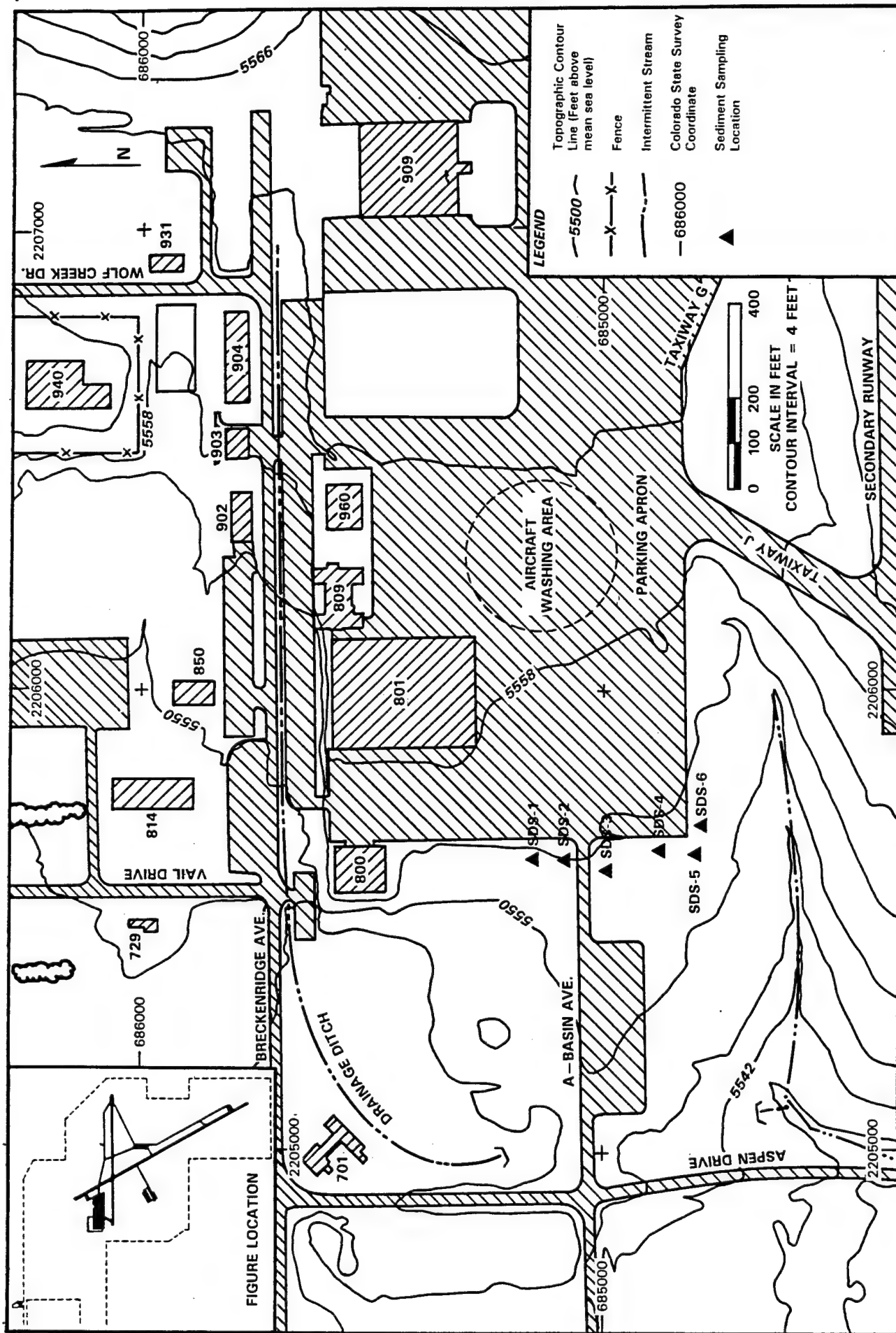


Figure 8-1 Field Activities for Site 5-Storm Drainage System, Colorado Air National Guard, Buckley Field, Aurora, Colorado

TABLE 8-2. REMEDIAL INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 5 - STORM DRAINAGE SYSTEM,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO

SITE	SAMPLE ACTIVITY/I.D.	ACTIVITY LOCATION	MATRIX	% MOIST	CHEMICAL ANALYSES SAMPLES										ANION CAT	GEOTECH (1) SAMPLES
					VOC	BNA	HERB	PEST	ICP MET	LEAD ONLY	PHOS NIT					
Sediment																
	SDS-1	Downstream of Wash Area	Soil	1	1	-	-	-	-	1 (2)	1	-	-	-	-	-
	SDS-2	Downstream of Wash Area	Soil	1	1	-	-	-	-	1 (2)	1	-	-	-	-	-
	SDS-3	Downstream of Wash Area	Soil	1	1	-	-	-	-	1 (2)	1	-	-	-	-	-
	SDS-4	Downstream of Wash Area	Soil	1	1	-	-	-	-	1 (2)	1	-	-	-	-	-
	SDS-5	Downstream of Wash Area	Soil	1	1	-	-	-	-	1 (2)	1	-	-	-	-	-
	SDS-6	Downstream of Wash Area	Soil	1	1	-	-	-	-	1 (2)	1	-	-	-	-	-

(1) - Geotechnical analyses included test for Atterberg limits, grain-size analysis, and vertical permeabilities.

(2) - Cadmium, Chromium, and Zinc only.

Table. 8-3 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SEDIMENT SAMPLES AT SITE 5- STORM DRAINAGE SYSTEM, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE	UNITS	Sample #SDS-1		Sample #SDS-2		Sample #SDS-3		Sample #SDS-3DUP		Sample #SDS-4		Sample #SDS-5		Sample #SDS-6	
		Assoc. QA/QC	Field:TB-8	Assoc. QA/QC	Field:TB-8	Assoc. QA/QC	Field:TB-8	Assoc. QA/QC	Field:TB-8	Assoc. QA/QC	Field:TB-8	Assoc. QA/QC	Field:TB-8	Assoc. QA/QC	Field:TB-8
		FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8	FB-8
		SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ	SDS-3EQ
VOLATILE ORGANICS (Method 8240)															
Methylene Chloride	ug/Kg	ND	5.32	6.71	5.33	ND	5.40	14.80	5.47	30.60	5.58	53.11	5.87	21.28	5.83
Ethyl benzene	ug/Kg	ND	5.32	ND	5.33	ND	5.40	ND	5.47	ND	5.58	141.07	5.87	ND	5.83
Total Xylenes	ug/Kg	ND	5.32	8.13	5.33	ND	5.40	ND	5.47	ND	5.58	4629.85*	5.87	ND	5.83
INORGANICS															
Z MOISTURE															
CHROMIUM, TOTAL	wt %	6	6.2	13	4.4	7.3	4.4	8.6	4.5	11	4.6	15	4.8	14	4.7
LEAD	mg/Kg	6.4	4.5	15	0.52	14	0.53	16	0.55	24	0.56	77	0.58	21	0.56
ZINC	mg/Kg	4.6	0.51	42	1.1	38	1.1	45	1.1	58	1.1	45	1.2	47	1.2

LEGEND

ND- Not Detected

*. Concentration is out of linear range

contamination. Total xylenes (8.13 µg/kg) were detected in SDS-2. Ethyl benzene (141 µg/kg) and total xylenes (4630 µg/kg) were detected in SDS-5. No other volatile organic compounds were detected in surficial soils at Site 5. Lead was detected above the 95% CI of background in four sediment samples. Lead was seven times the 95% CI of background, which may correspond with the higher concentrations of fuel-related volatile organic compounds found in this sample. No other metals were detected at levels exceeding the 95% CI of the background measurements, and all metals (including lead) were within the expected natural ranges.

8.5 SUMMARY OF FINDINGS

Volatile organic compounds were detected at two sampling locations (SDS-2, SDS-5), and may be associated with runoff flowing off the parking apron. Lead was detected in four sampling locations above the 95% confidence interval of local background samples and expected concentration ranges for soils. However, all lead concentrations were within expected natural background ranges for soils.

8.6 RISK ASSESSMENT RESULTS

8.6.1 Soil and Sediment Exposure Risks

Table 8-4 presents the results of the risk assessment for Site 5 sediments. The table first provides a summary of mean levels of chemical contaminants observed in sediments at the site under investigation. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects which was calculated taking into account the calculated dose. The third column describes the target organs for potential noncarcinogenic effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

As shown in Table 8-4, the hazard indices for any subject chemical does not exceed 1.0. In addition, the hazard indices for combined exposure across chemicals is also less than 1.0. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to compounds in the Site 5 sediments for Base personnel, or for children hypothetically exposed offsite. No potentially carcinogenic chemicals were detected in the sediments under evaluation.

Table. 8-4 . RISK CHARACTERIZATION FOR SITE 5: EXPOSURE TO SEDIMENTS

COMPOUND	Mean Concentration in Sediment (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic				
Beryllium				
Cadmium				
Chromium	15.00	2.94E-03	Skin	
Copper				
Lead	25.00	1.75E-02	CNS, Kidney	
Mercury				
Nickel				
Phosphorous				
Selenium				
Silver				
Thallium				
Zinc	42.00	2.06E-04	Anemia	
ORGANICS				
Ethylbenzene	0.22	2.16E-06	Skin, Liver, Kidney	
Xylenes	0.67	3.26E-07	CNS	

Hazard Index: Combined Exposure		2.07E-02		
Excess Lifetime Cancer Risk: Combined Exposure				

- a. Mean of 7 samples. Mean concentrations were determined treating "not detected" results as if the chemical was present at half the detection limit.
- b. Dose calculated assuming ingestion exposure to contaminated surface soil on-site.
Exposure assumptions: inadvertent ingestion of 0.1 grams of soil/day, by Base personnel: 70 kg adult exposed 5 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

8.7 CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the RI data confirmed the SI data that indicated no sediment contamination was present in the storm drainage system adjacent to Building 801. Sediment samples taken downstream of the aircraft washing area, the suspected source of any contamination at this site, show no widespread contamination. Elevated levels of petroleum hydrocarbon and associated lead contamination were detected in only one of the six samples collected. Field reconnaissance found no widespread areas that appeared to have been affected by any contamination. The one contaminated sample was collected in a small, shallow depression adjacent to the aircraft parking area. It represents an extremely localized area of contamination. A baseline public health evaluation showed no significant risk associated with the contaminated soil. Therefore, no further immediate action is necessary at this site. The drafting of a decision document should await the sampling of the alluvium at the discharge of the ditch.

9.0 SITE 6 - FORMER SEWAGE TREATMENT PLANT

This section provides information specifically pertaining to Site 6. This includes past investigation activities, RI objectives and activities performed, the results and significance of RI findings, risk assessment results, and conclusion and recommendations. Background information of past activities is provided in Sections 9.1 and 9.2. Results of IRP Phase II, Stage 1, Part 2 activities are presented in "Installation Restoration Program Phase II-Confirmation/Quantification Stage 1, Buckley Air National Guard Base, October 16, 1985 to November 5, 1985" (Dames & Moore 1987).

9.1 SITE DESCRIPTION AND PREVIOUS WORK

The purpose of the Installation Restoration Program (IRP) Phase I (preliminary assessment) was to identify the type and location of past waste disposal practices at Buckley ANGB and to assess potential for contaminant presence and migration. This phase consisted primarily of interviews and record review. No maps or drawings of the site were found.

The Sewage Treatment Plant was in operation from 1942 to 1978 when the sludge digester roof collapsed and the plant was closed. Reportedly, the plant was subject to occasional "slugs" of chemical wastes, including water containing petroleum products, organic solvents, trace metals, and pesticides (Dames & Moore 1987).

The plant consisted of bar screens, a primary clarifier, a trickling filter, a sludge digester, chlorine contact chambers, and sludge drying beds. Treated effluent from the plant was discharged to Sand Creek. The sludge drying beds, which were rarely cleaned, were designed with a filtrate collection system; however, the clay tiles comprising this system collapsed early in its life (Simons, Li, & Associates, Inc. 1982). Due to their permeable bottoms, the trickling filters and sludge drying beds presented a potential route of contamination via leakage and infiltration to groundwater.

IRP Phase II, Stage 1, Part 2, Confirmation/Quantification (Site Inspections)

Field investigations were conducted at Site 6, the Sewage Treatment Plant. Activities at the Former Sewage Treatment Plant included the installation and sampling of three monitoring wells and three soil borings.

Chemical analyses of soils and groundwater from this site (see Table 9-1) indicated that contamination was present based on concentrations of phenolics (up to 360 mg/kg) in soil samples, and trichloroethylene (TCE; 4 µg/l), chloroform (2 µg/l) and bromodichloromethane (1 µg/l) in groundwater samples. Again, however, the analytical results for lead in soil samples were inconclusive due to matrix effects.

The Site Inspection did not determine background contaminant concentrations, or confirm the presence and extent of lead or other contaminants at this site. Information needed to complete

TABLE 9-1. ANALYTICAL RESULTS FOR SITE 6 - FORMER SEWAGE TREATMENT PLANT

Parameter (Sample Depth-Feet)	Method	Unit	Detection Limit	Groundwater Samples		Soil Samples					
				MW-1	MW-2	B-1 (41.5- 42.5)	B-1 (46.5- 43.5)	B-2 (44- 45)	B-3 (39- 40)	B-3 (49- 50)	B-3 (54- 55)
Chloride	325.2 ^a	mg/l	1	110	160						
Chloroform	601 ^c	ug/l	1	ND	2						
Bromodichloro- methane	601 ^c	ug/l	1	ND	1						
Trichloroethene	601 ^c	ug/l	1	4 ^d	ND						
Phenolics	420.2 ^a	ug/l	10	10	30	ND	287	361	333	ND	ND
Moisture											
Content	160.3 ^a	Percent	1			8	6	3	4	36	35
pH	Field	Std	0.1	7.4	7.3						
Temperature	Field	°C	0.1	13.5	14						
Specific											
Conductance	Field	umhos/cm	1	3500	3300						

^a Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.^b Test Methods for Evaluating Solid Waste, SW-846, 2nd ed., July 1982, Modified for use on 0.1. Corp. Model 610 TOX Analyzer.^c Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA-600/4-82-057, July 1982.^d A second column confirmation was performed.

ND - indicates value less than detection limits.

Source: Dames & Moore 1986 and 1987. "Installation Restoration Program, Phase II - Confirmation/Quantification, Stage 1".

data gaps included determining the extent of contamination, and sludge, soil, and sediment characterization. Recommendations were to resample the well during the times of higher groundwater elevations and analyze samples to determine whether the low levels of contamination detected can be sustained.

9.2 REMEDIAL INVESTIGATION ACTIVITIES

Remedial investigation activities were based upon findings of the Preliminary Assessment (Phase I Records Search) and two earlier investigations (Phase II Stage 1, Parts 1 and 2-Confirmation/Quantification). Objectives of the RI were to:

- Determine if contamination of the various environmental media at Site 6 is present
- Identify the source(s) and nature of any contamination present
- Determine the extent, magnitude, and movement of any contamination present
- Assess the risk any present contamination may pose to public health, thereby determining the need for remedial actions.

RI Part 1 activities performed at Site 6-Former Sewage Treatment Plant, included:

- Drill, sample, and abandon four soil borings
- Sample groundwater at two previously installed wells.
- Sediment sampling (3 locations)

Locations of field activities are shown in Figure 9-1. A listing of sampling parameters is presented in Table 9-2. No additional field work was performed during the RI Part 2 at Site 6.

9.3 SITE ENVIRONMENTAL SETTING

Figure 9-2 depicts a geologic profile through Site 6 - Former Sewage Treatment Plan. The sediments encountered during drilling at this site consist of a surficial 5-ft loess deposit underlain by silt, sands, and clays of the Denver Formation. Water levels are nearly 50 ft BLS, the deepest anywhere studied on the Base. Groundwater flow directions cannot be determined because one of the previously installed wells was dry, but there is a component of groundwater flow in the northwesterly direction based upon measurements within the other two existing wells. No other hydrologic data is available for this site because of the existing wells small size and generally poor condition.

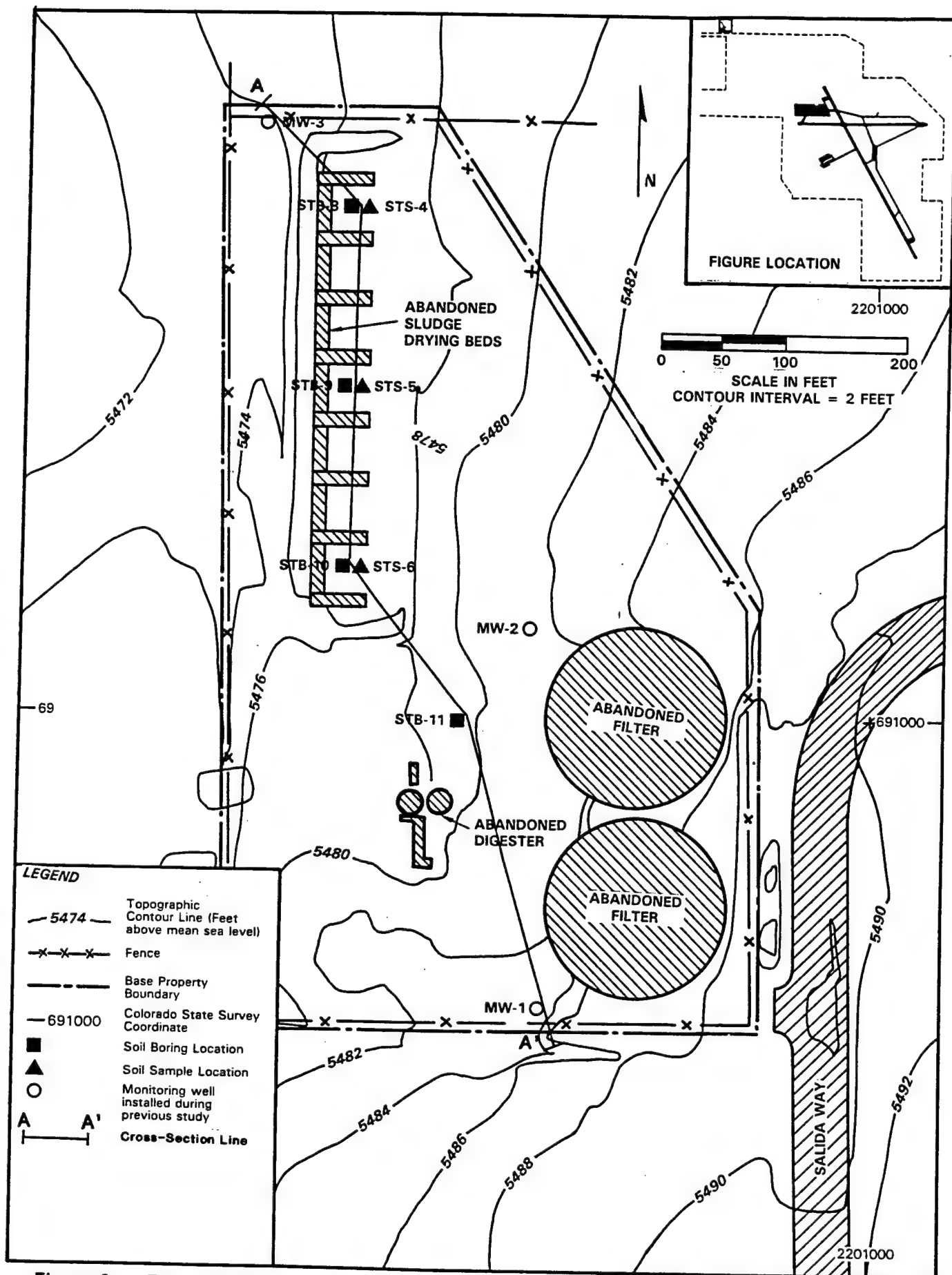


Figure 9-1 Field Activities for Site 6-Former Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado

TABLE 9-2.REMEDIATION INVESTIGATION SAMPLE ANALYSIS SUMMARY FOR SITE 6 - FORMER BASE SEWAGE TREATMENT SYSTEM,
BUCKLEY FIELD, COLORADO AIR NATIONAL GUARD, AURORA, COLORADO

SITE	SAMPLE ACTIVITY/I.D.	ACTIVITY LOCATION	MATRIX	% MOIST	CHEMICAL ANALYSES SAMPLES										GEOTECH (1) SAMPLES
					VOC	BNA	HERB	PEST	ICP MET	LEAD ONLY	PHOS NIT	ANION CAT			
Sediment															
	STS-4	Sludge Drying Bed	Soil	1	-	-	-	-	-	1	-	1	-	-	
	STS-5	Sludge Drying Bed	Soil	1	-	-	-	-	-	1	-	1	-	-	
	STS-6	Sludge Drying Bed	Soil	1	-	-	-	-	-	1	-	1	-	-	
Soil Boring Boreholes															
	STB-8	Sludge Drying Bed	Soil	2	-	-	-	-	-	2	-	-	-	3	
	STB-9	Sludge Drying Bed	Soil	2	-	-	-	-	-	2	-	-	-	-	
	STB-10	Sludge Drying Bed	Soil	2	-	-	-	-	-	2	-	-	-	-	
	STB-11	Adj. to Digester	Soil	2	-	-	-	-	-	2	-	-	-	-	
Groundwater															
	MW-1 (2)	Upgradient	Water	-	1	1	1	1	1	1	-	-	1 (3)	-	
	MW-2 (2)	Within Site	Water	-	1	1	1	1	1	1	-	-	1 (3)	-	

- (1) - Geotechnical analyses included test for Atterberg limits, grain-size analysis, and vertical permeabilities.
(2) - Monitoring wells installed during a previous study.
(3) - Cations only

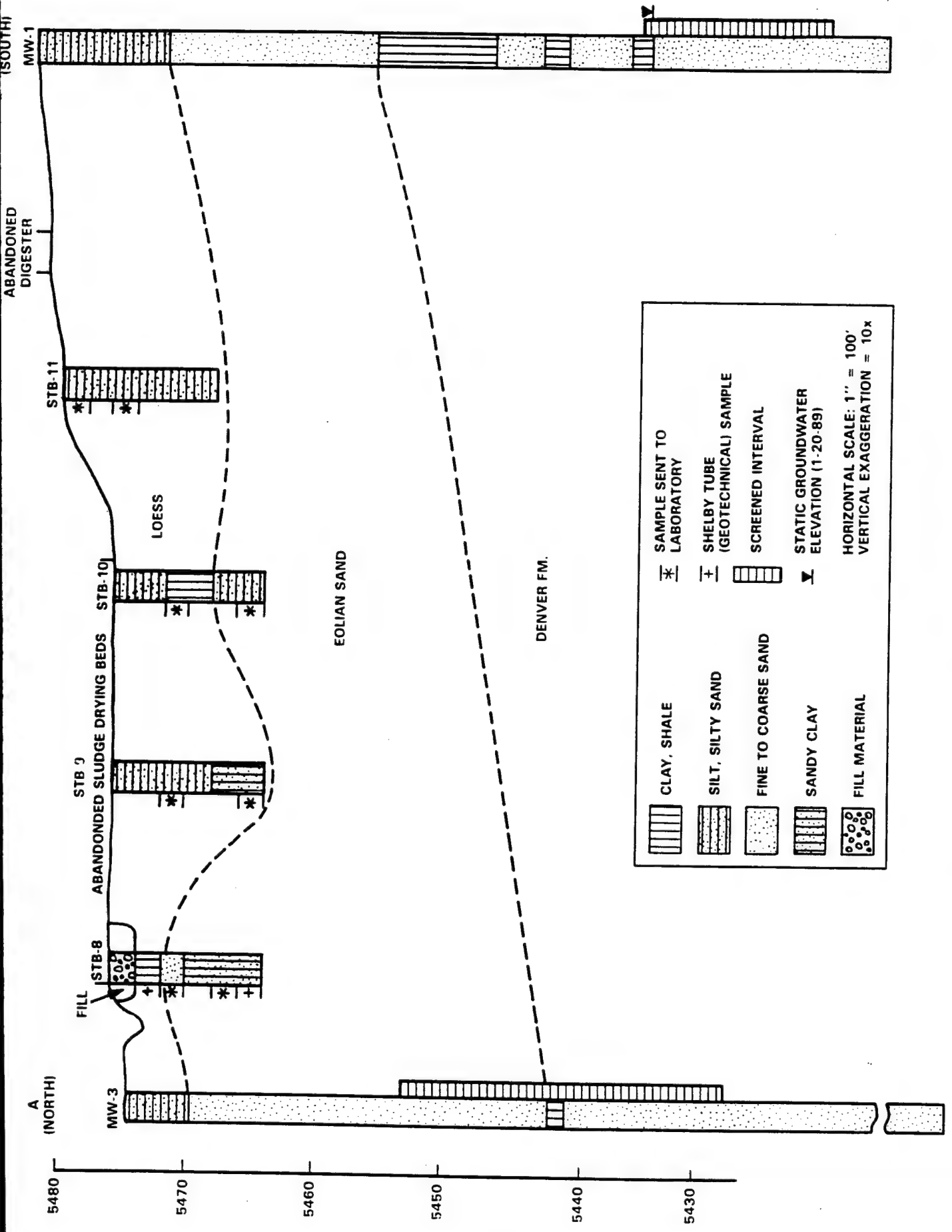


Figure 9 -2 Generalized Geologic Profile A-A' of Site-6 Former Sewage Treatment Plant, Colorado Air National Guard, Buckley Field, Aurora, Colorado.

9.4 SIGNIFICANCE OF FINDINGS

9.4.1 Surficial Sediment Sample Results

Three surficial sediments were sampled during the RI Part 1 at Site 6. The objective of sampling these sediments was to determine if sludges discharged from the Former Base Waste Treatment Plant contaminated the surficial soils in the adjacent area. Figure 9-1 shows surficial sediment sampling locations.

Table 9-3 summarizes the RI Part 1 laboratory analysis results. Only Hg, of all the priority pollutant metals, was detected above either the 95% CI of the background samples or above the expected range. However, mercury was close to detection limits, and is not considered an environmental contaminant.

9.4.2 Soil Boring Soil Sample Results

Soils from four soil borings were sampled during the RI Part 1 at Site 6. The objective of the soil borings was to investigate whether soils in and under the sludge drying beds and soils adjacent to the sludge digester were contaminated and whether any contamination could be migrating deeper into the alluvial soils. Figure 9-1 shows the location of soil borings at Site 6.

Table 9-4 summarizes the RI Part 1 analytical results for Site 6. Three boreholes (STB-8, STB-9, and STB-10) showed elevated levels of priority pollutant metals in soils from 5 ft BLS: STB-8 showed high concentrations of chromium (16.1 mg/kg), lead (30.1 mg/kg), mercury (0.85 mg/kg), and silver (10.9 mg/kg); STB-10 showed high concentrations of chromium (62.4 mg/kg), lead (59.0 mg/kg), mercury (1.67 mg/kg), and silver (22.3 mg/kg); STB-9 had levels of thallium above the 95% CI of the background concentration in soils from 5 and 10 ft BLS (24.9 and 29.5 mg/kg, respectively). No other priority pollutant metals were detected above either the 95% CI of the background or the expected natural ranges. All metal concentrations decrease (with the exception of thallium in STB-9) with depth in each borehole. The detected priority pollutant metal levels above the 95% CI of the background, and natural ranges (Table 9-4) merit further consideration (mercury, silver, and thallium).

9.4.3 Groundwater Sample Results

Two previously existing monitoring wells (MW-1 and MW-2) were sampled and analyzed with the objective of determining if contaminants from the Former Sewage Treatment Plant have entered the groundwater under Site 6. Figure 9-1 shows the location of the two monitoring wells.

Table 9-5 summarizes the RI Part 1 analytical results from Site 6. Methylene chloride was detected in both samples. However, this compound is a common laboratory contaminant and is not considered to represent environmental contamination at this site. No other volatile or semivolatile contaminants were detected in water samples from Site 6.

Table. 9-3 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SEDIMENT SAMPLES AT SITE 6- FORMER BASE
SEWAGE TREATMENT PLANT, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE	UNITS	Sample #:STS-4		Sample #:STS-5		Sample #:STS-5DUP		Sample #:STS-6	
		Assoc. QA/QC	TB-1	Assoc. QA/QC	TB-1	Assoc. QA/QC	TB-1	Assoc. QA/QC	TB-1
			FB-1		FB-1		FB-1		FB-1
			EQ-1		EQ-1		EQ-1		EQ-1

ANALYSIS	REPORTING ANALYSIS	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT

VOLATILE ORGANICS (Method 8240)									
			NA		NA		NA		NA

SEMI-VOLATILE ORGANICS (Method 8270)									
			NA		NA		NA		NA

INORGANICS									
% MOISTURE	wt %		7.0		7.5		11.8		9.7
ARSENIC	mg/kg		2.3		2.4		3.3		2.8
BERYLLIUM	mg/kg		0.4		0.8		0.5		0.2
CALCIUM	mg/kg		31,000		3,620		18,900		62,800
CHROMIUM	mg/kg		14.0		17.6		18.0		14.9
COBALT	mg/kg		5.2		5.8		5.7		5.0
LEAD	mg/kg		11.3		15.0		12.2		9.2
MERCURY	mg/kg		0.35		0.31		ND	0.25	0.26
NICKEL	mg/kg		11.5		11.3		15.5		11.6
NITROGEN (KJELDAHL)	wt %		0.29		0.072		0.25		0.065
PHOSPHOROUS	mg/kg		1700		672		746		695
ZINC	mg/kg		109		75.9		67.5		58.8

LEGEND

ND- Not Detected

NA- Not Analyzed

Table. 9-4 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 6- FORMER BASE
SEWAGE TREATMENT PLANT, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

ANALYTE	UNITS	Sample #:STB-8(5)			Sample #:STB-8(10)			Sample #:STB-9(5)			Sample #:STB-9(10)			Sample #:STB-10(5)			Sample #:STB-10(10)				
		Assoc. QAQC	TB-1	FB-1	EQ-1	Assoc. QAQC	TB-1	FB-1	EQ-1	Assoc. QAQC	TB-1	FB-1	EQ-1	Assoc. QAQC	TB-1	FB-1	EQ-1	Assoc. QAQC	TB-1	FB-1	EQ-1

ANALYSIS REPORTING ANALYSIS REPORTING ANALYSIS REPORTING ANALYSIS REPORTING ANALYSIS REPORTING ANALYSIS																					
		RESULT	LIMIT		RESULT	LIMIT		RESULT	LIMIT		RESULT	LIMIT		RESULT	LIMIT		RESULT	LIMIT		RESULT	LIMIT

VOLATILE ORGANICS (Method 8240)																					
		NA			NA			NA			NA			NA			NA			NA	

SEMI-VOLATILE ORGANICS (Method 8270)																					
		NA			NA			NA			NA			NA			NA			NA	

INORGANICS																					
	</																				

LEGEND

ND - Not Detected

NA - Not Analyzed

Table. 9-4 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES AT SITE 6- FORMER BASE
SEWAGE TREATMENT PLANT, COLORADO AIR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO
(Continued)

Sample #:STB-10(10)Dup Sample #:STB-11(0.5)Sample #:STB-11(5)									
		Assoc. QAQC		Assoc. QAQC		Assoc. QAQC		Assoc. QAQC	
		TB-1		TB-1		TB-1		TB-1	
		FB-1		FB-1		FB-1		FB-1	
		EQ-1		EQ-1		EQ-1		EQ-1	

ANALYTE	UNITS	ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING		ANALYSIS REPORTING	
		RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT	RESULT	LIMIT

VOLATILE ORGANICS (Method 8240)									
			NA		NA		NA		NA

SEMI-VOLATILE ORGANICS (Method 8270)									
			NA		NA		NA		NA

INORGANICS									

% MOISTURE	wt %		13.6		9.5		10.9		
ARSENIC	mg/kg		2.0		2.9		1.9		
BERYLLIUM	mg/kg		0.8		0.3		1.3		
CALCIUM	mg/kg		13500		50,300		42,800		
CHROMIUM	mg/kg		10.6		15.8		14.4		
COBALT	mg/kg		6.0		5.2		6.2		
LEAD	mg/kg		10.8		14.0		11.9		
MERCURY	mg/kg		ND	0.25	0.25		ND	0.25	
NICKEL	mg/kg		7.3		14.6		11.3		
SELENIUM	mg/kg		ND	0.2	ND	0.2	ND	0.2	
SILVER	mg/kg		ND	2.0	ND	2.0	ND	2.0	
THALLIUM	mg/kg		ND	20	ND	20	ND	20	
ZINC	mg/kg		60.4		54.7		61.9		

LEGEND

ND- Not Detected
NA- Not Analyzed

Table. 9-5 SUMMARY OF INORGANIC AND ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES AT SITE 6- FORMER BASE
SEWAGE TREATMENT PLANT, COLORADO ATR NATIONAL GUARD, BUCKLEY FIELD, AURORA, COLORADO

Sample #: MW-1(SITE 6)Sample #: MW-2(SITE 6)					
		Assoc. QA/QC		Assoc. QA/QC	
		TB-9		TB-9	
		FB-8A		FB-8A	
		MW-1EQ		MW-1EQ	
ANALYTE		UNITS	ANALYSIS RESULT	REPORTING LIMIT	ANALYSIS RESULT
FIELD ANALYSIS					
pH	units	7.11	7.37		
Temperature	deg. C	11.5	12		
Conductivity	umhos/cm	3310	2940		
VOLATILE ORGANICS (Method 8240)					
Methylene Chloride	ug/L	54.82 B,HB	5.0 11.6* J B HB	5.0	
SEMI-VOLATILE ORGANICS (Method 8270)					
		ND	ND		
CHLORINATED PESTICIDES					
		ND	ND		
CHLORINATED HERBICIDES					
		ND	ND		
INORGANICS					
CALCIUM	ug/L	380,000	50	33,000	50
COPPER	ug/L	ND	30	63	30
LEAD	ug/L	7.9	5	ND	5
MAGNESIUM	ug/L	49,000	200	32,000	200
MERCURY	ug/L	ND	5	ND	0.2
POTASSIUM	ug/L	4700	19	10,000	19
SELENIUM	ug/L	61	2	110	2
SODIUM	ug/L	570,000	900	470,000	900
ZINC	ug/L	37	10	72	10

LEGEND

- ND- Not Detected
- NA- Not Analyzed
- B- Compound was reported present in the laboratory method blank
- HB- Compound was reported present in the laboratory holding blank
- J- Estimated value because one surrogate percent was outside controll limits
- *. Concentration is out of linear range

No priority pollutant metals were detected over maximum contaminant levels (MCLs) except for selenium (61 and 110 mg/l in MW-1 and MW-2, respectively). However, Se has been detected above the MCL in wells near the Base. High Se concentrations may also be caused by high amounts of suspended solids in the samples. No cations exceeded State of Colorado standards, where specified, (Colorado Department of Health 1971), and hardness calculations were within concentration ranges expected for the alluvial aquifer near the Base (Hillier et al. 1983).

9.5 SUMMARY OF FINDINGS

No priority pollutant metals were detected in the surface sediments at concentrations above the 95% confidence interval for local background samples except for mercury. However, the mercury was detected at levels close to reporting limits, and is therefore not considered an environmental contaminant.

Chromium, lead, mercury, and silver were detected in two soil borings (STB-8, STB-9) at 5 ft BLS in concentrations exceeding the 95% confidence level for local background samples. Thallium was detected above the 95% confidence interval for local background samples at 5 and 10 ft BLS in STB-9. Chromium and lead are within natural background ranges, but mercury and silver are outside natural background ranges. Thus mercury, silver, and thallium may require a risk assessment to determine the significance of their presence.

No volatile or semivolatile organic compounds were detected in the groundwater. Selenium was detected above MCLs, but was within ranges detected in wells near the Base.

9.6 RISK ASSESSMENT RESULTS

9.6.1 Groundwater Consumption Risks

In order to examine the magnitude of this contamination a summary table, Table 9-6, has been prepared showing mean and maximum levels of inorganic toxicants in groundwater at Site 6. Since no detectable quantities of organic substances were detected, there are no ARAR tables for that type of contaminant. For comparison, the applicable or relevant and appropriate requirements (ARAR; i.e., federal and state water-quality criteria and standards) are included. As specified in the Superfund Amendments and Reauthorization Act of 1986 (SARA), on-site remedial actions are required to attain ARARs unless such requirements are formally waived. Referring to Table 9-6, it can be observed that the reported concentration of selenium exceeds the ARAR level. The elevated selenium levels may be caused by conditions not associated with waste disposal practices (see Section 3.2). The concentrations of copper, lead, mercury and zinc do not exceed ARAR levels or TBC guidelines, although the concentration of mercury is very close to the MCL and Colorado Drinking Water Standard. There are no known ARARs or TBC guidelines for calcium, magnesium, potassium, and sodium. Since all detected quantities of organic and inorganic compounds are below ARAR levels or TBC guidelines, or there is a reasonable explanation (not related to hazardous material disposal

TABLE 9-6. ARARS FOR INORGANIC CHEMICALS FROM SITE 6 GROUNDWATER AT THE BUCKLEY ANG8

Inorganic Constituent	Mean Concentration (ug/L)	Maximum Concentration (ug/L)	Drinking Water		Drinking Water MCLG (ug/L)	Adjusted for Drinking Water Only (ug/L)	Colorado Drinking Water Standards (ug/L)		Federal Water Health Advisories (g)		
			MCL (ug/L)	MCLG (ug/L)					One-Day 10 kg (ug/L)	Ten-Day 10 kg (ug/L)	Longer-Term 70 kg (ug/L)
Calcium	206,500	380,000		1,000 ^(e)	1,300 ^(d)	1,000 ^(f)		1,000			
Copper	39	63		50	20 ^(d)	50		50			
Lead	5.2	7.9									
Magnesium	40,500	49,000									
Mercury	1.3	1.3		2	3 ^(d)	10		2	1.58	1.58	N/A
Potassium	7,350	10,000									
Selenium	86	110		10	45 ^(d)	10		10			
Sodium	520,000	570,000									
Zinc	55	72		5,000 ^(e)		5,000 ^(f)		5,000			

(a) Maximum Contaminant Levels established under the Safe Drinking Water Act.

(b) Maximum Contaminant Level Goal established under the Safe Drinking Water Act.

(c) Ambient Water Quality Criteria established under the Clean Water Act, adjusted for drinking water.

(d) Proposed MCL or MCLG.

(e) Secondary Maximum Contaminant Level (SMCL) established under the Safe Drinking Water Act - not an ARAR.

(f) Criterion established based on taste and odor effects (organoleptic) not human health effects.

(g) Federal Drinking Water Health Advisories are not ARARs, but values to be considered (TBC) in evaluating the significance of observed levels of contamination in drinking water supplies.

(h) Drinking Water Health Advisory for a 10 kg child.

(i) Drinking Water Health Advisory for a 70 kg adult.

(j) Mean concentration of groundwater from Site 6. Mean values were calculated treating "not detected" results as if the subject chemical was present at half the detection limit.

or handling practices) for the occurrence of elevated levels - a risk characterization was not conducted for the groundwater-consumption pathway.

9.6.2 Soils and Sediments Exposure Risks

Table 9-7 and 9-8 present the results of the risk assessment for Site 6. The tables first provide a summary of mean levels of chemical contaminants observed in soils and sediments at this site under investigation. Based on these mean values, estimates of chronic dose are developed. The second column presents the hazard index for noncarcinogenic effects which was calculated taking into account the calculated dose. The third column describes the target organs for potential carcinogenic effects. The fourth column presents the measure of excess lifetime probability of cancer. Risk estimates are provided separately for exposure to each chemical and then for combined exposure across all chemicals for a given site.

Derivation of cancer risks are based on estimates of the "reasonable maximum exposure" (as defined in the revised National Contingency Plan 53 FR 51394) to receptors at potential risk. These estimates are measures of hypothetical risk to a maximally exposed individual. At this site, risks are characterized separately for exposure to each environmental media; soils and sediments. Risk estimates are not aggregated for simultaneous exposure across soils and sediments.

The results of the risk assessment must be interpreted in the context of these exposure assumptions/scenarios. Much of the uncertainty in the results may be attributed to the assumptions established as the basis of the exposure assessment.

As shown in these two tables, the hazard indices for any subject chemical exceed 1.0. In addition, the hazard indices for combined exposure across chemicals is also less than 1.0. No adverse noncarcinogenic effects would therefore be anticipated following chronic exposure to compounds in soils or sediments for Base personnel, or for children hypothetically exposed offsite. Only one potentially carcinogenic chemical was detected in soils under evaluation. Looking again at the summary table, it can be seen that the excess lifetime risk of cancer does not exceed 5×10^{-7} . Based on EPA guidelines under CERCLA/SARA, and given the very conservative exposure assumptions used in the assessment, this risk level would be considered to fall within the acceptable range.

9.7 CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the RI groundwater data did not confirm the low levels of VOCs detected in the groundwater samples collected during the SI. No groundwater contamination was detected at this site. Several inorganic compounds were detected, but are consistent with natural background levels. However, because the previously installed extreme downgradient monitoring well was dry, no sample downgradient of the sludge drying bed was collected. However, levels of priority pollutant metals above background concentrations were found at the 5-ft depth in soils within the sludge drying beds.

Table. 9-7. RISK CHARACTERIZATION FOR SITE 6: EXPOSURE TO SEDIMENTS

COMPOUND	Mean Concentration in Sediment (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic	2.70	1.06E-03	Skin, Lung	5.30E-07
Beryllium	0.50	3.92E-05	Lung, Skin, Heart	
Cadmium				
Chromium	16.10	1.26E-03	Skin	
Cobalt	5.40			
Copper				
Lead	11.90	3.34E-03	CNS, Kidney	
Mercury	0.26	3.40E-04	CNS	
Nickel	12.50	2.45E-04	Skin, Lung	
Phosphorous	953.00			
Selenium				
Silver				
Thallium				
Zinc	78.00	1.53E-04	Anemia	
ORGANICS				
Ethylbenzene				
Xylene				

Hazard Index: Combined Exposure		6.44E-03		
Excess Lifetime Cancer Risk: Combined Exposure				5.30E-07

a. Mean of 4 samples. Mean concentrations were determined treating "not detected" results as if the chemical was present at half the detection limit.

b. Dose calculated assuming ingestion exposure to contaminated surface sediments.

Exposure assumptions: inadvertent ingestion of 0.1 grams of soil/day, by Base personnel: 70 kg adult exposed 2 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

Table. 9-8 RISK CHARACTERIZATION FOR SITE 6: SOIL EXPOSURE

COMPOUND	Mean Levels in Soil (a) (mg/kg)	Noncarcin. Effects: (b) Hazard Index (Dose/RfD)	Noncarcinogenic Effect of Concern	Excess Lifetime Individual Carcinogenic Risk (Dose x q1*)
INORGANICS				
Arsenic	1.90	7.46E-04	Skin, Lung	3.73E-07
Beryllium	0.80	6.28E-05	Lung, Skin, Heart	
Cadmium				
Chromium	24.00	1.88E-03	Skin	
Cobalt	4.60		Lungs, Skin	
Copper				
Lead	25.20	7.06E-03	CNS, Kidney	
Mercury	0.60	7.85E-04	CNS	
Nickel	10.30	2.02E-04	Skin, Lung	
Phosphorous				
Selenium	0.14	1.83E-05	Liver, Kidney, Skin	
Silver	7.24	9.47E-04	Liver, Kidney, CNS	
Thallium	13.00	7.29E-02	Liver, Kidney, CNS	
Zinc	86.00	1.69E-04	Anemia	
ORGANICS				
Acenaphthalene				
Anthracene				
Ethylbenzene				
Fluorene				
2-Hexane				
Methylene Chloride				
2-Methylnaphthalene				
Naphthalene				
Nitrobenzene				
N-Nitrosodiphenylamine				
Phenathrene				
1,1,2,2-Tetrachloroethane				
Tetrachloroethylene				
Toluene				
1,1,1-Trichloroethane				
1,1,2-Trichloroethane				
Trichloroethylene				
Xylenes				

Hazard Index: Combined Exposure		8.48E-02		
Excess Lifetime Cancer Risk: Combined Exposure				3.73E-07

- a. Mean of 5 samples. Mean concentrations were determined treating "not detected" results as if the chemical was present at half the detection limit.
- b. Dose calculated assuming ingestion exposure to contaminated surface soil on-site.
Exposure assumptions: inadvertent ingestion of 0.1 grams of soil/day, by Base personnel; 70 kg adult exposed 2 days per week, every week. 11 months per year, (1 month period of no snow cover), 20 years of a 70 year lifetime.

No priority pollutant metal soil contamination was found in soils outside of the drying beds. Metals found at elevated levels were chromium, mercury, silver, and thallium, which can be attributed to concentration of metals within the sludge during the sewage treatment process.

Even though there was no downgradient groundwater sample, this fact does not affect the conclusions for the site. Only the sludge drying beds are monitored by this extreme downgradient well, and soil boring data clearly show that contamination within these beds consists of priority pollutant metals which are limited to soils above the 8-ft depth, well above the approximate 50-ft depth of the potentiometric groundwater surface. Therefore, this site has been adequately monitored to detect the extent of contamination at the site and affected media. A baseline public health evaluation indicates that there is no significant risk associated with metal soil contamination in the sludge drying beds. Therefore, no further action is necessary at this site and a decision document should be drafted to eliminate the site from further IRP study.

LIST OF ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFFF	Aqueous Film-Forming Foam
ANGB	Air National Guard Base
ARARs	Applicable or Relevant and Appropriate Requirements
AVGAS	Aviation Gas
AWQC	Ambient Water Quality Criteria
BLS	Below Land Surface
DOD	Department of Defense
EPA	U.S. Environmental Protection Agency
FTA	Fire Training Area
GC	Gas Chromatography
GPD	Gallons Per Day
I.D.	Inside Diameter
IRP	Installation Restoration Program
MCLs	Maximum Contaminant Levels
MCLGs	Maximum Contaminant Level Goals
MGD	Million Gallons Per Day
MOGAS	Motor Vehicle Gas
MSL	Mean Sea Level
NGB	National Guard Bureau
NRC	National Research Council
O.D.	Outside Diameter

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

OWRS	Office of Water Regulations and Standards
PCE	Tetrachloroethylene
ppt	Parts per Thousand
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
RMCLs	Recommended Maximum Contaminant Levels
RPD	Relative Percent Difference
SAIC	Science Applications International Corporation
TCA	Trichloroethane
TCE	Trichloroethylene
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TRC	Tracer Research Corporation
VOC	Volatile Organic Compound

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